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ABSTRACT

Modern society is very dependent upon numerous chemical substances. Chemicals have a wide variety of uses, including drugs to prolong our lives and pesticides to control insect and weed pests. Life would be drastically different without the availability of these chemical substances but, while the benefits of chemicals should be appreciated, the hazards they present to our health and to the health of the environment should also be taken into account. Most chemicals are safe when manufactured, transported, and used properly, but when they are mishandled or misused, they can threaten both the health of humans and the health of wildlife. In this book, some common chemicals used in society and the conditions under which some of these chemicals are dangerous are reviewed. The benefits of these chemicals, some problems they can cause, and how their harmful effects can be reduced or avoided are also discussed. (CW)

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Toxic Substances in the Environment

Second Edition



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In memory of
Ken Arrington

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Preface

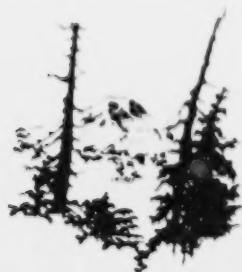
In the Huxley College of Environmental Studies at Western Washington University, those involved in a seminar class on educating the public about toxic substances formed the Toxic Substances Education Group. The group of students, bachelor degree candidates in Environmental Education, Environmental Health and Scientific Illustration, at Western Washington University, and a professor, a teacher and research scientist in the field of Environmental Toxicology, decided to work together to write a textbook. The product of this year-long collaboration and subsequent additions is the text before you, *Toxic Substances in the Environment*.

This text provides up-to-date and informative reading material on toxic chemicals. By providing such information, we hope to inspire you to learn about toxic substances and, by knowing more, to help protect human health and environmental quality. It is hoped that you will find this textbook interesting and readable. We encourage you to make comments: likes, dislikes and suggestions. This information will be used in future revisions of *Toxic Substances in the Environment*.

Since many of the words used in this book may be new to you, a glossary is provided at the end. All of the italicized words are important to the discussion of toxicology and they are included in the glossary, along with some other words you may want to learn.

It is worth all of our best efforts to protect ourselves and the environment from the harmful effects of toxic chemicals.

Toxic Substances Education Group
February, 1983



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Introduction

Our modern society is very dependent upon numerous chemical substances. Chemicals have a wide variety of uses, including drugs to prolong our lives and pesticides to control insect and weed pests. There is no doubt our lives would be drastically different without the availability of these chemical substances. But while we should appreciate and enjoy the benefits of chemicals, we must also take into account the hazards they present to our health and to the health of the environment.

Most chemicals are safe when manufactured, transported, and used properly, but when they are mishandled or misused, they can threaten both the health of humans and the health of wildlife. The study of how chemicals can cause harmful health effects in organisms is called *toxicology*, and that is what this book is about. In this book, you will learn about some common chemicals used in our society, and how under certain conditions some of these chemicals are dangerous. You will learn about the benefits of these chemicals, about some problems they can cause, and how we can reduce or avoid their harmful effects.

Because there are so many chemicals in use today, the need to study their effects has expanded. Therefore, as a science, toxicology is becoming increasingly important. Toxicological studies have shown, for

instance, that some human diseases can result from the *exposure* of people to chemicals in the environment. *Cancer*, one of the most dreaded diseases, can be caused by man-made chemicals. In this book, you will read about some important cancer causing chemicals, including vinyl chloride, PCBs, and dioxin.

Wildlife have also suffered from toxic chemicals that man has introduced into the environment. Consider the insecticide DDT, which was used heavily in this country for many years. Although DDT was a highly effective insecticide, it took many years for people to understand that it could *accumulate* in food chains and result in harmful effects in some animals. The process of food-chain accumulation of toxic substances can lead to high concentrations of chemicals in various parts of *ecosystems*. In the case of DDT, the chemical eventually reached harmful levels in eagles and caused them to lay eggs with thin shells, which can result in the death of developing embryos.

The ecosystem concept is an important one and we will discuss it in this book. Ecosystems consist of living components (people and wildlife) and nonliving components (water, rocks, and chemicals) interacting with each other. Human activity in an ecosystem can have far-reaching effects. If a lake is contaminated with sewage, for example, there can be an impact on many organisms, such as fish, algae, fish-eating birds and mammals.

By learning about chemicals, we can learn to use them properly in our lives. Did you know that some common chemical products used in your home may be deadly if they are misused? You can learn to spot situations where others are using hazardous chemicals unsafely, and you can warn them of the potential danger. In some cases, it has only taken a few well-informed persons to point out the hazardous effects of a chemical, thus preserving the health of many people. It is important for us to learn about chemicals because we all have the responsibility to make sure that the environment and all living things remain safe from damage by toxic chemicals.

Our government makes laws to protect workers from chemical contamination in the workplace, to protect our drinking water and food supply, and to protect wildlife and plants from unsafe chemical contamination. But because of the large number and volume of chemicals in use today, it is often impossible for federal, state, and local governments to protect us from all hazardous exposures to toxic chemicals. So it is important for all of us to know enough about toxic chemicals to be able to protect our own health and to keep the environment safe for wildlife.



1 Pesticide Problems: Missing the Target

What are pesticides? The suffix “-cide” means to kill; therefore, the word pesticide means pest killer. Organisms that feed on or interfere with the growth of valuable agricultural crops and other plants preferred by humans are referred to as pests. They can be insects or weeds, so we have *insecticides* to kill pest insects and *herbicides* to kill pest plants. Though these two types of pesticides are meant to kill different organisms, they do have some common characteristics.

Many pesticides are sprayed over crops from a duster plane. The sprayed chemical falls to the ground as droplets or dust. This pesticide spray may settle directly on the crops, but some of it may remain in the air and drift with the wind for miles before it settles. This is one

reason why pesticides have been found in places miles away from the place where they were originally sprayed.

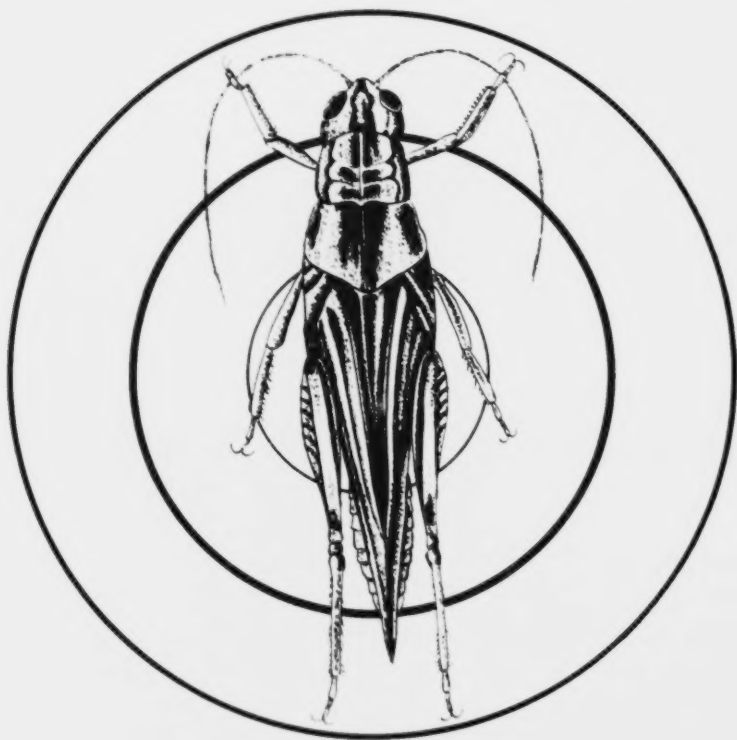
When the pesticide does settle to the ground, it can remain in the same molecular form as when it was applied or it can break down into other molecular forms, or simpler chemicals, with the help of sunlight, heat, water and micro-organisms. These substances that remain after pesticide application are called pesticide *residues*. Residues may or may not be *toxic* depending on the molecular characteristics of the individual pesticide chemical. Pesticide residues may remain in the soil, in river sediments, or in plant leaves and exhibit toxic characteristics for days, months or even years after their application.

Over time, pesticide residues can be washed from the soil and leaves by rainfall or irrigation water. From the sprayed fields, the rain water flows into streams. This process is called *runoff*. These streams can then carry the pesticide residues for very long distances. Even salt water fish, far from any pesticide application, sometimes have pesticide residues in their bodies. This indicates the wide environmental distribution of pesticide chemicals.

Pesticides are usually made to kill specific organisms, called *target organisms*. The pesticides become a problem when they poison plants or animals that are not meant to be killed; these are called *non-target organisms*. Unfortunately, the chemicals cannot tell which organisms are which and so non-target organisms can potentially be harmed after a pesticide application. Non-target organisms may be birds, small mammals, fish or even people. These animals can be *exposed* to a pesticide in a variety of ways: it may be eaten (*ingested*), breathed (*inhaled*), or it may contact the surface of the skin, thereafter entering an animal's bloodstream.

Once exposed to enough pesticide, the non-target organism may develop some symptoms of poisoning. The two major kinds of poisoning are *acute* and *chronic*. Acute poisoning is a quick response to large doses of a poison, such as a pesticide, after only a short period of time (hours to days). Chronic poisoning is a response to smaller doses of a

poison over a longer period of time (months to years). Both acute and chronic poisoning, which results from exposure to pesticide chemicals, can cause serious diseases or even death to many organisms, including wildlife and human beings.



Insects, like the grasshopper, that can cause significant destruction of agricultural crops are the "target pests" of insecticide chemicals. Environmental problems occur when the insecticide also harms exposed "non-target" plants and animals.

What Are Insecticides?

Insecticides are used to kill pest insects. Insecticide chemicals are used primarily in agriculture. They help to reduce the crop damage caused by insects. Let's take a look at two insecticides, endrin and parathion, to see how they are used and what happens to them in the environment.

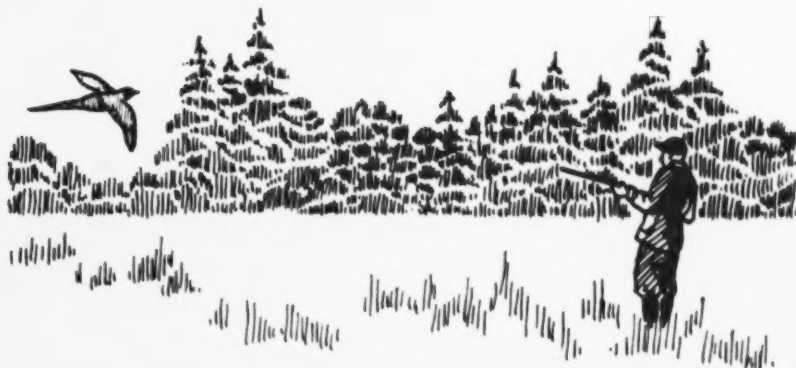
What is endrin?

Endrin is an insecticide used to control insect pests that eat wheat, cotton, fruit and other crops. Endrin can remain in the soil for years after application and in biological systems, such as fish and wildlife, for weeks or months. This *persistence* increases the possibility, and maybe the seriousness, of endrin poisoning.

What are the problems with endrin?

Endrin becomes a problem when it enters the *food chain*. A food chain is a relationship where one animal or plant is eaten by another animal, which is in turn eaten by a larger animal, and then a larger animal, etc. Through this process, poisons can be transferred through the chain to cause harm to animals at each level.

In March of 1981, 121,000 acres of wheat in Montana were sprayed with endrin, as were another 140,000 acres in Colorado, Wyoming and South Dakota. The target pest was the cut-worm, which eats wheat seedlings. A problem was discovered when geese and ducks also began eating the sprayed wheat-seedlings. The *toxin* was accumulating in the birds' fat tissue and skin. When hunters shot contaminated birds and shared the meat with family and friends at the dinner table, there was the possibility that all who ate endrin-contaminated meat had also ingested small amounts of endrin.



Game birds contaminated with endrin may be shot and then eaten by unsuspecting hunters.

Such small amounts of endrin would probably not be enough to result in observable symptoms of poisoning. Still, endrin is considered to be a poisonous substance and each person should try to avoid or at least minimize their own intake.

What are the symptoms of endrin poisoning?

The symptoms vary with the *dose*. They can range from loss of muscle control and drowsiness to *convulsions*, unconsciousness and death. Endrin is highly toxic; for instance, a teaspoon of endrin, if eaten, would probably kill you.

What is parathion?

Parathion was developed in Germany after World War II. It is a variation of nerve gas, a chemical warfare agent. Parathion is used to control pest insects such as the aphids and mites that eat agricultural crops. It is used to protect fruit, vegetables and grain products from these insect pests.

FOCUS: *Birds can't always fly away from pesticides*

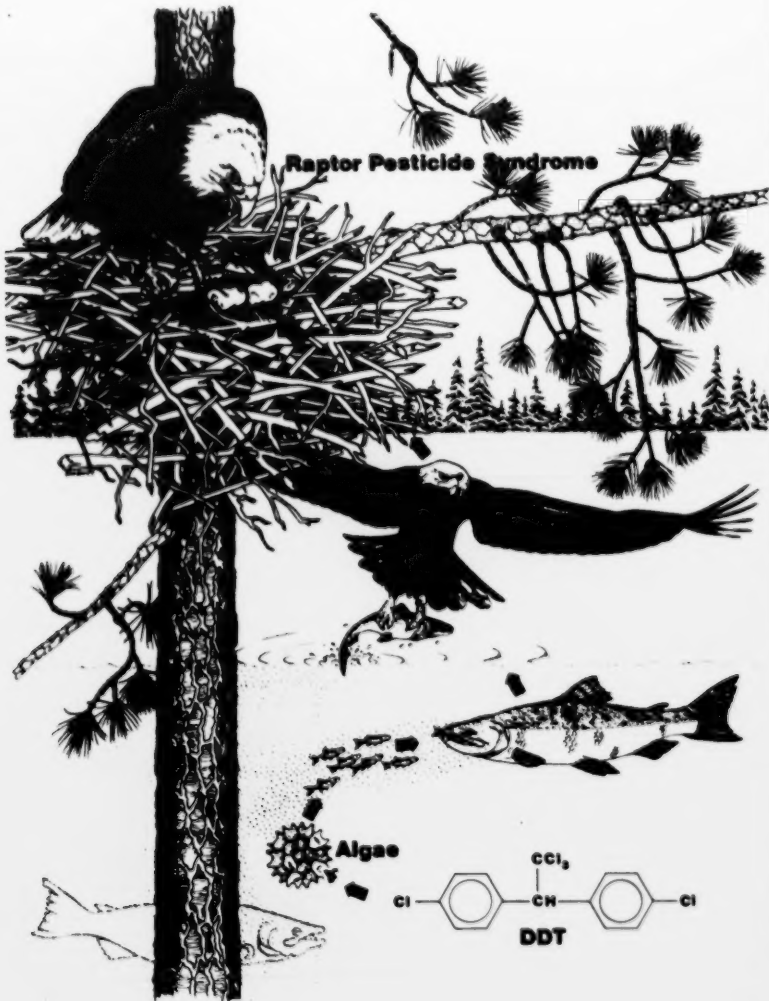
Often, a bird's only protection from natural dangers is its mobility—its ability to fly away. However, the mobility of birds is often not adequate to escape pesticide exposure because pesticides are often used throughout the bird *habitat*, leaving no place to escape.

Birds are harmed by pesticides through direct and secondary poisoning. Direct poisoning can occur by skin contact with the toxic spray. Secondary poisoning occurs when the bird eats a fish or other food source that is contaminated with a pesticide.

Bird avoidance of pesticides is also restricted by the behavior patterns of birds. At night, birds often return to a favorite roost to sleep. If pesticides are applied to these roosting sites, especially at night, the birds will be exposed and may die as a result. Pheasants and other game birds have been found dead in roosting areas after they were exposed to pesticides.

During the nesting season, birds are even more restricted in avoiding pesticides because they must stay near their nests. Pesticide spray may poison parent birds and either kill them or cause their reproductive behavior to be disturbed and they may leave their nest. If the parents abandon their nest, the eggs may never hatch. Chicks that do hatch are more vulnerable to poisoning while they are young. It often takes a smaller amount of pesticide to cause the death of a young bird than an older one.

Bald eagles, like this one, are birds of prey, which means they eat fish and small mammals. Eagles and other similar birds, like the osprey and peregrine falcon, are also called raptors. Raptor Pesticide Syndrome, illustrated here, is a disruption in the reproductive process of these birds. In this specific case, an insecticide called DDT contaminated the fish eaten by the eagles and caused the eagles' eggshells to become thin. This eggshell thinning can result in the death of developing embryos.



Why is parathion a problem?

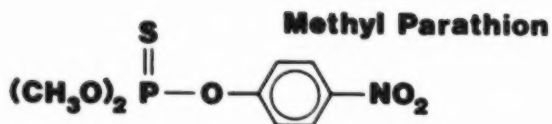
Like other pesticides, parathion causes problems because it kills both target and non-target organisms. People are usually exposed to parathion while working near it. This may occur at a factory that makes the insecticide, when it is transported from the manufacturer to the farm, or when it is actually used in the fields. In contrast to endrin, parathion residues generally break down and lose their toxic activity relatively quickly in the environment. Therefore, human consumption of parathion is rare because by the time crops are harvested, packaged and transported to the supermarket, the chemical has usually broken down into non-toxic components.

What happens when a person is poisoned by parathion?

Parathion is so toxic that one teaspoon of this pesticide placed on a person's skin is enough to result in death. This chemical attacks the *nervous system*, which includes the brain. Even if a person has not been exposed to enough parathion to cause death, other symptoms can occur. Acute symptoms range from headache, dizziness, and weakness, to severe coughing, vomiting, breathing difficulties and convulsions. Death is usually by suffocation because the muscles used for breathing become paralyzed after excessive parathion exposure.

What about animals?

Animals that are experiencing parathion poisoning have symptoms similar to those of humans. Fish that swim in water contaminated with parathion may develop kidney and liver damage. If the poisoning becomes severe, they will have trouble swimming. Poisoned fish will gulp for air at the surface and will die when their gills become paralyzed and can no longer take in oxygen.



Birds exposed to parathion can suffer from high heart and breathing rates, which are stressful to their bodies. Bird eggs contaminated with parathion may fail to hatch or the chicks may hatch with birth defects. Death may also result if birds are exposed to sufficient levels of parathion.

Is there any protection from parathion?

Workers can protect themselves from parathion by wearing masks, long sleeves, pants and gloves while working with this toxic



Protective clothing should be worn by people who use or work near toxic chemicals. Sometimes, only protective masks and gloves are necessary. For extremely toxic chemicals, however, a full suit of protective clothing is required to ensure safety.

chemical. There are government regulations that prohibit unprotected people from entering a field within a certain period of time (48 hours, for example) after pesticide spraying. The same standards also prohibit spraying of fields if unprotected people are in the area or if high winds will carry the insecticide to unprotected people in neighboring areas.

For wildlife, there is no real protection from exposure to parathion. They are protected only if the chemical is not used or if the chemical does not enter into the places where animals live.

What Are Herbicides?

Herbicides are used to kill pest plants. Herbicides are often used in areas where a forest has been cleared to provide land for crops. They control weeds that grow quickly on this cleared land. Herbicides are also used along highways, railroads and powerlines to control weed growth, as well as in lakes and rivers to control aquatic weeds. Two commonly used herbicides are 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid).

2,4-D and 2,4,5-T damage the growth of a plant by affecting growth hormones. A growth hormone is a chemical in the plant that controls growth. 2,4-D and 2,4,5-T act as artificial growth hormones causing abnormal growth in the plant. The plant develops a very long stem, little or no roots and very few small leaves. Without enough leaves, the plants can't generate sufficient energy through *photosynthesis* and they die.

Do herbicides stay in the soil?

Herbicides usually evaporate quickly after they are applied, and therefore, are lost into the air. Herbicide chemicals are also lost when rainfall washes them off the land into streams. This means that the herbicides often must be reapplied to effectively kill the pest plants.

FOCUS: *Herbicides and Nitrates—an important interaction*

Nitrates are inorganic substances, which means they do not have carbon atoms in their chemical structure. Some weeds, such as ragwort, pigweed, Canada thistle and sugar beet produce nitrates. Many animals cannot tolerate nitrates and these nitrate-producing plants can be poisonous. But nature protects the animals by making such poisonous plants taste unpleasant, so grazing animals, such as cows, will avoid them. Spraying 2,4-D or 2,4,5-T on these weeds can cover the bad taste because the herbicide increases the sugar content in the plant, making them taste sweet. Therefore, grazing animals may eat these sprayed plants and be poisoned. Inside the cow's rumen (part of the stomach) the ingested nitrates are converted into highly toxic compounds that are capable of producing severe illness or death.



Ragwort

What pest problems increase with use of herbicides?

Herbicides have been known to cause imbalances in natural systems, which can result in unexpected problems. By eliminating broadleaf pest plants, herbicides may cause increased growth of other pest plants not killed by the herbicides, such as grasses and foxtails. Herbicides may also promote diseases on crops, including tomato blight and viruses on cucumbers, cotton, and tobacco.

How do herbicides affect beneficial insects?

Herbicides, like 2,4-D, can be harmful to beneficial insects. 2,4-D is toxic to lady bugs, which are valuable to farmers and gardeners because they eat aphids, a pest insect.

Honeybees will go elsewhere when flowering plants, their source of nectar, are killed by herbicides, including 2,4,5-T. Since the bees will move elsewhere in search of nectar, they will not be available later to *pollinate* crop plants that might be near areas treated with 2,4,5-T. Plants must be pollinated for reproduction to occur. If pollination does not occur in agricultural crops, crop production can decrease.



What are the effects of herbicides on mammals?

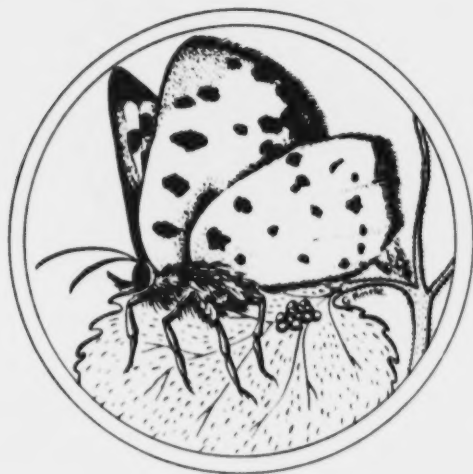
Laboratory tests on mice, rats and rabbits show that 2,4,5-T can cause birth defects and higher than normal death rates in young. Tests with sheep and cattle indicate that 2,4-D causes problems with muscle control. After large doses of 2,4-D, the normal temperature of animals cannot be maintained under extreme weather conditions. In cold temperatures, the herbicide prevents shivering. Shivering is a normal muscle response that increases body temperature so that an animal can maintain normal body temperature during cold weather.

What is special about nettles?

Nettles are usually considered pest-weeds. The herbicide 2,4,5-T is used to control them. But nettles play an important part in the lives of some animals. Certain types of butterflies use nettles for food when they are caterpillars. Adult butterflies lay their eggs on a nettle plant, and the eggs hatch into caterpillars, which feed upon the plant. Nettles also provide a winter home for other beneficial insects. Thus, nettles are a pest to humans but, at the same time, they are beneficial for some insect species.

What Is Dioxin?

During the manufacture of the herbicide 2,4,5-T, an impurity called dioxin can be produced. Dioxins are one of the most toxic man-made materials known. They contaminate many other products besides 2,4,5-T, including paints, varnishes, paper and paper coatings, and even some shampoos. Dioxins are released into the environment during manufacture, use or disposal of these products. Since toxicological tests show dioxin to be extremely hazardous to humans and wildlife, and since this substance can enter food chains, scientists are concerned about dioxins in the environment.



Butterflies lay their eggs on the nettle plant, a pest plant to humans but a beneficial plant for the butterflies.



After the butterfly eggs hatch, the larval stages or caterpillars, feed on the leaves of the nettle.

Studies of the effects of dioxin on rats and mice show that it can cause birth defects in these animals. In one study, 2,4,5-T contaminated with dioxins was given to pregnant rats for nine days. This treatment caused a variety of birth defects in the young, including enlarged livers and diseased kidneys. In other tests, rats and mice were born without heads and eyes. Dioxin is also thought to be a potential human *carcinogen*, which means it can cause cancer in people.

What are the effects on humans?

Dioxins may cause miscarriages in pregnant women. A miscarriage is the loss of a dead or unhealthy human fetus very early in its development. Recently, there were reports of an increase in miscarriages that was possibly related to the use of dioxin-contaminated 2,4,5-T in a forested area in Oregon. After six years of use, beginning in 1974, the rate of miscarriages in women living in the treated area appeared somewhat higher than would be normally expected. Although there is the possibility that dioxins could have caused these miscarriages, a clear cause/effect relationship (meaning that certain levels of dioxin exposure were determined to result in miscarriages) was never identified.

In 1978, a twelve-year-old girl in Oregon developed a rare blood disease after the area around her home had been sprayed with 2,4,5-T. Herbicide residues of 2,4,5-T were found in her blood and in the family's drinking water. Five other families shared the same water source; one member of each of these families developed cancer. Though there appears to be a relationship between exposure to 2,4,5-T and the development of blood disease or cancer, here again, there is no reliable scientific evidence indicating a definite cause/effect relationship.

FOCUS: *Agent Orange—Herbicide in war*

During the Vietnam War of the 1960s, a chemical weapon called "Agent Orange" was used. Agent Orange was a mixture of the two herbicides 2,4-D and 2,4,5-T. It was used to destroy vegetation in the dense jungles of Vietnam, which assisted American soldiers in fighting the enemy.

It has been estimated that over 100 million pounds of Agent Orange were used during the war. Most herbicide spraying was over forests, but other areas, including farmlands, were also sprayed. Many of the effects of the spraying are still visible today and it may take decades for some of the sprayed areas to return to normal.

Although the toxic residues of Agent Orange were probably gone within a year after spraying, dioxin, an impurity of 2,4,5-T, remained in the soil. Dioxin residues may have caused large scale effects on forests and wildlife as well as on humans. After the spraying of Agent Orange, forests often showed decreased numbers of birds for several years. This was probably due to the lack of living trees to provide forest birds with homes and food. It is also possible that the dioxin residues were toxic to the birds and caused their deaths.

People living in areas sprayed with Agent Orange were exposed to the chemical. Many miscarriages and birth defects have been reported among Vietnamese women who lived near sprayed areas. Pregnant women who drank water contaminated with Agent Orange may have received a dose equivalent to 600 times as much as the amount considered safe in the United States.

American soldiers may have been exposed to hazardous amounts of the herbicide, too. Some children of Vietnam veterans exposed to Agent Orange have been born with circulation problems, cancer, and other defects. These abnormalities could be associated with exposure to Agent Orange, although this is difficult to prove scientifically.

The effects of Agent Orange should be studied further.





Are There Alternatives to Pesticides?

Monocultures are the most common form of farming and forestry in the United States. The prefix "mono-" means one and a monoculture is the farming of a single kind of crop, such as wheat. This practice was developed to make harvesting easier and quicker, and to increase production.

This may sound desirable, but several problems are associated with monocultures. Large fields planted with only one crop strongly attract the insects, viruses and fungi that attack that specific crop. The pests spread easily and can destroy much of the crop in a short time. Therefore, pesticide use becomes necessary for controlling the large populations of harmful pests that plague these fields.

There are alternatives to monocultures that do not require heavy use of pesticides. Organic farming is an example of an alternative to the monoculture method of farming. What is organic farming? Organic is anything related to living organisms; therefore, such material as animal waste and dead plants is organic matter. Organic farming uses animal by-products to fertilize the growth of crops.

Organic farming uses the "recycling" process. Think of the two words: "return" and "cycle." This illustrates the meaning of recycle: the idea of returning nutrients to the soil. Plants are harvested and their

unused portions are returned to the soil. Livestock graze on other crops and the return of their manure nourishes the soil.

The organic farmer plants a variety of crops. Different plants return various important nutrients to the soil. The aim of the organic farmer is to have healthy soil. Healthy soil makes healthy crops, and healthy crops are more resistant to attack by pests.

How are pests controlled on organic farms?

A method of pest control that fits very well with organic farming is *Integrated Pest Management* (IPM). IPM uses a wide variety of plants and insects to create a more natural system. The natural balance between climate, soil and insect populations can help to prevent an insect from overpopulating an area and destroying a particular crop.

An important part of maintaining a natural balance is to allow a variety of plants to grow in the field. When using IPM, the farmer attempts to maintain several types of weed growth to provide an attractive environment for a variety of insects. With the presence of many insect species, predators that feed on pests can keep the population of harmful species from reaching pest levels. The IPM farmer tries to keep from killing all of the pests, because the predator of a pest would then have no more food and would leave the field. With the predator gone, pests would eventually return to the field and flourish at the expense of the crops.

One of the most important parts of an IPM program is for the farmer to know exactly which insects are harmful to the crops, which insects are beneficial predators, and which insects cause no harm. This means the farmer using IPM must spend time walking through the fields keeping notes on which insects are present.



FOCUS: *An organic farmer*

At one time, a farmer named Richard Thompson used the intensive monoculture method of farming. His corn crop monoculture brought many weed and insect problems that pesticides didn't seem to control. His farm animals were sick more often than they were healthy. He switched to the organic farming method and he recently commented:

"My farm has been organic since then, and I notice that it farms better and has better drainage. I don't use herbicides and I don't have weed problems. I don't use insecticides and I'm not troubled by corn rootworms. Now health is the rule and sickness the exception for my livestock."

Mr. Thompson uses a corn-beans-oats-hay rotation to maintain healthy soil and control the foxtail weed. While he is harvesting each of his crops, the weeds are controlled by picking them before they can seed.

He has found that he saves money (approximately \$430.00 per acre) by no longer using chemical fertilizers, herbicides, and other pesticides. Now, his fertilizer is made from corn cobs and other plant waste, some manure from his livestock and a yearly application of a hay and alfalfa combination called "green manure."

FOCUS: *The advantage of weeds*

"What is a weed? A plant whose virtues have not yet been discovered."

Ralph Waldo Emerson

Generally, weeds are considered useless, but in many ways they are important to the environment. Vigorous growing weeds are valuable soil conditioners. The roots penetrate deeply, breaking up the subsoil, thereby releasing nutrients to other plants. The roots also hold soil in place and prevent erosion.

Some weeds purposely associate with various garden plants, improving their taste and giving them greater resistance to disease. For this reason, native Americans grew morning glory alongside corn. Lupine improves the quality of corn as well, and wild mustard improves growth of fruit trees and grape vines. Dandelions grown near fruits stimulate them to ripen quickly.

Once the farmer knows which insects are harmful, information must be gathered about those insects. It is important to know their life cycles: when they mate, when they reproduce, and how long they live. Sometimes planting a crop a little earlier in the season will avoid the appearance of pests. For instance, tomatoes grown in the San Joaquin Valley in California, if planted early, between February and March, can mature in time to escape most of the tomato fruit worm damage. This is because the tomato fruit worm doesn't become a threat in that area until September or October.

There are alternatives to the use of pesticides. If the soils are kept naturally fertile and healthy through organic methods, and a wide variety of plants and insects are allowed to grow, nature can find a healthy balance between them all. The farmer's job is more difficult, but more interesting, when pesticides are not used. Instead of simply spraying pesticide chemicals, he must study the balance of nature and attempt to maintain that balance in the fields. A program using organic farming and IPM can produce healthy crops, maintain a stable ecosystem and prevent harmful chemicals from harming other animals or people.

FOCUS: *Circle of poison*

The industrial world regularly exports pesticides to Third World nations, even some kinds that are banned here in the U.S., like DDT. Some pesticides have restricted usage in the U.S., like 2,4,5-T, but are used without restraint in other countries. Often pesticides are used on Third World food crops that are then exported back to the United States. Therefore, we continue to be supplied with food contaminated by the pesticides that are banned here at home.

Summing Up

The two kinds of pesticides studied here are known as insecticides and herbicides. They both form residues in the soil and can be washed into streams, which may carry them hundreds of miles from their source. The residues may persist in the soil and on the bottoms of lakes and rivers. Pesticides can poison target and non-target organisms alike. Exposure occurs through ingestion, inhalation, and skin contact. Exposure can result in acute or chronic poisoning.

Chemical pesticides are used to protect and increase production of natural resources, including food and fiber products. The use of pesticides grows as the world population grows. It is important to understand the problems and dangers that accompany the use of these chemicals.

Questions for Review

1. Which insecticide persists in the soil and biological systems the longest, parathion or endrin? Why is this persistence significant?
2. Why might a concentration of toxin be higher in carnivores than herbivores?
3. How are humans usually exposed to parathion?
4. Why would it be important for a farmer to consider weather conditions before application of a pesticide?
5. Why would it be important to have warnings and instructions on herbicides and other pesticides specifically when using them around farms or woodlands?
6. Explain how pesticides can endanger fish and other aquatic organisms. How can pesticides reach marine fish?
7. How might deer and other animals be affected by 2,4-D and 2,4,5-T?
8. In using Integrated Pest Management (IPM) is it necessary to kill all of the harmful pests?
9. Why is the monoculture method of farming not good for the soil?
10. Why do organic farmers put cow manure on their fields?



2 Heavy Metals: Very Useful, Very Toxic

The metals are a group of elements sharing certain special characteristics. Metals conduct heat and electricity, they reflect light, they can be shaped by beating with a hammer, and many are silver or greyish-white in color (copper and gold are exceptions). Several metals are needed in small amounts by organisms for maintaining good health. These are called "trace metals" and include such elements as iron, copper, zinc, nickel, chromium, and tin. Each of these metals has a specific role to play in the chemistry of living things. Iron, for instance, is needed

by animals because it is used by red blood cells in the transport of oxygen throughout the body. The metal chromium is helpful in digesting sugars that provide energy for life processes.

In contrast to trace metals, certain other metals interfere with the chemical processes in organisms and appear to have no known nutritional value. Metals such as cadmium, lead, and mercury are highly toxic in small amounts. These metals are often referred to as the "toxic heavy metals." We find many uses for these metals in our modern society, and the more they are used, the greater is the chance they will contaminate our food, air and water. This chapter will discuss some of the uses and dangers of two of these toxic metals: lead and mercury.

What Is Lead?

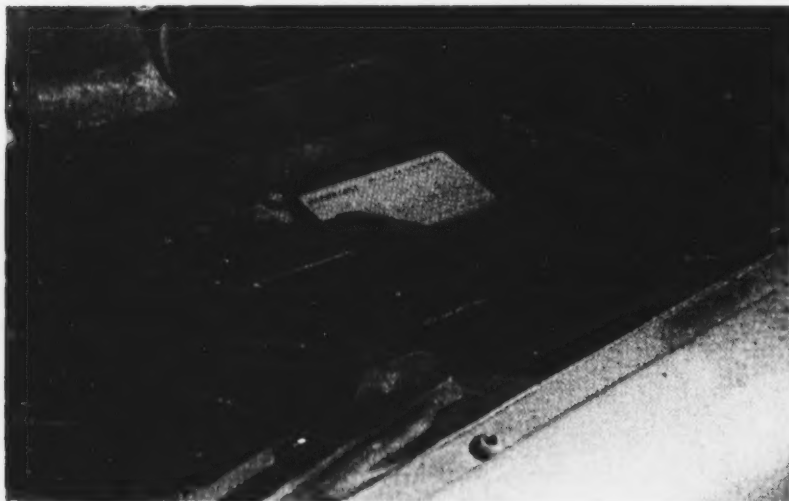
Lead is a soft metal that is easily shaped and resistant to corrosion. It is a fairly abundant metal and can be extracted easily from its ore, galena. It will combine chemically with other elements to form a variety of *compounds* with unique and useful properties. Lead's beneficial characteristics have made it useful to man for at least 4,000 years. But lead often presents a serious health *hazard*. It is important that people know how they can be exposed to lead so its toxic effects can be avoided.

How is lead used?

Early Romans were the first people to use lead on a large scale. During the time of the Roman Empire, about 2,000 years ago, lead was used to make water pipes and eating utensils because it was easy to work with. This extensive use of lead probably caused significant contamination of food and water because many Romans are known to

have experienced lead poisoning. Researchers have found very high levels of lead in recovered bones of the early Romans. Some historians think that lead poisoning caused insanity in Roman leaders and may be one of the reasons the empire was defeated.

Today, we use copper or plastic for our water pipes, and other metals for our eating utensils, but we still find lead in many other products. Forty percent of the lead used today goes into lead-acid electrical storage batteries. The lead-acid battery is a dependable and convenient method for storing electricity and is essential in starting a car's engine. The second major use of lead is as an additive to gasoline. Lead improves the burning characteristics of gasoline in the internal combustion engine found in most cars, preventing the problem of "knocking." Other important uses of lead are in the solder that seals metal cans, in bullets and shotgun shells, in roofing materials, in pipes that carry corrosive liquids, and as a pigment in paint.



A major use of lead is in the production of lead-acid car batteries.

How are organisms exposed to lead?

Even though the largest use of lead is in batteries, little of the lead used for this purpose escapes into the environment. The greatest source of lead contamination in the environment is the combustion of lead-containing fuels. Coal and fuel oil burned for heating and industrial purposes releases some lead into the environment, but the major source is the combustion of leaded gasoline in cars and trucks.

In the atmosphere, lead from gasoline accounts for 90% or more of the total amount present. As much as 180,000 tons are released into the air in the United States every year from this source. Most of this lead is concentrated near streets and highways. Plants and animals living near areas of heavy traffic have been found to contain high levels of lead as a result of this contamination.



Leaded paint is another important source of lead contamination. Lead is no longer used in indoor paints, but it used to be, and many older houses and apartment buildings still have leaded paint on their walls. Small children often have a tendency to eat paint chips. Since some buildings, especially in poorer neighborhoods, may have walls

covered with cracking leaded paint, a health danger exists. A good-sized paint chip could give a small child a toxic dose of lead. Although recovery from lead poisoning is possible, permanent brain damage and mental retardation may result.

Some cities have set up programs to deal with this problem. The level of lead in children is measured, and those children that are suspected of having or are experiencing lead poisoning are treated. Additionally, walls are painted with nonleaded paint in areas where lead poisoning is a problem.

The use of lead in pesticides, especially lead arsenate, in the past has resulted in high concentrations of lead in some areas, particularly in apple orchards. Compounds of lead were used as pesticides for many years in the United States and the contamination of many lakes and streams has resulted.

Lead poisoning is an important cause of the death of wild ducks and geese. Waterfowl can ingest lead because lead shot from hunters' guns rests on the bottoms of many lakes that these birds visit to feed. Waterfowl mistakenly swallow the pellets while they are gathering food off the bottom of a shallow pond or edge of a lake. Lead from pellets that are swallowed by the birds may enter their bloodstreams and can result in death.

Lead poisoning is also a common occurrence in cattle. Cattle are extremely curious animals and often investigate foreign objects by licking and chewing them. Lead-bearing paints, plasters, greases, and batteries sometimes find their way into pastures where cattle may ingest them.

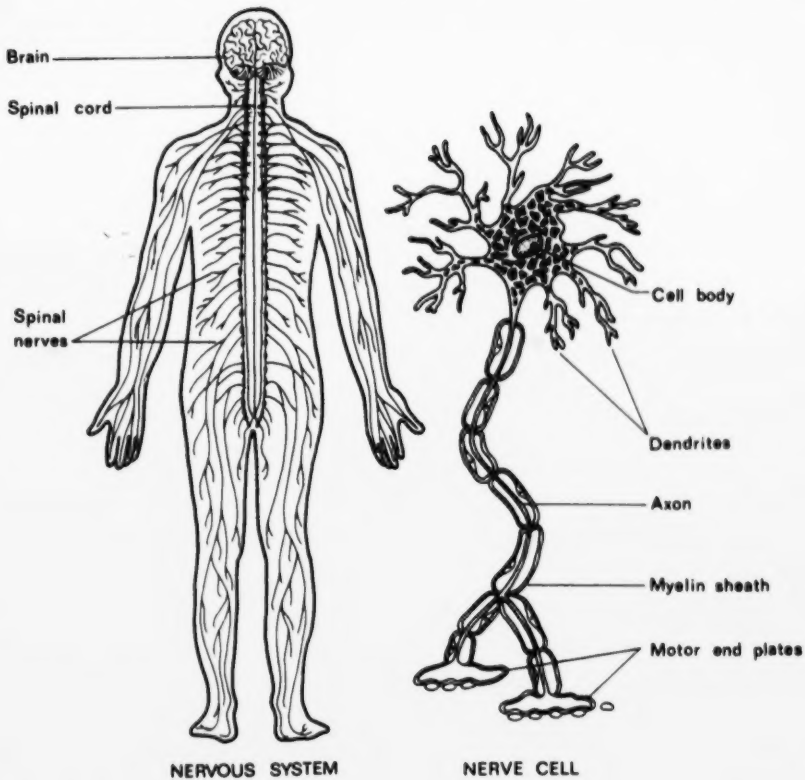
What are the effects of lead on animals?

Most of the lead *absorbed* by birds and mammals is stored in bone tissue where it replaces the element calcium. However, lead in the *circulatory system* affects the red blood cells, which carry oxygen to all parts of the body. There is evidence that lead shortens cell life



Lead shot, used in shotgun shells, can fall onto the ground or into a pond or lake when the shells are fired. The lead pellets can then be mistakenly eaten by waterfowl or other birds, like the mourning dove. Once ingested, the lead can cause poisoning and even death.

and prevents iron from entering red blood cells. This decreases the oxygen-carrying capability of the blood. If enough oxygen is not supplied to the body, sufficient energy will not be produced. Therefore, lead-poisoned animals will often look weak and tired. This weakened con-



dition can be associated with "anemia", a condition of red blood cell deficiency and a symptom of lead poisoning.

Other early symptoms of lead poisoning are headaches, muscle pains, clumsiness, and irritability. The poisoned individual often becomes restless, easily distracted, and impulsive. Pain develops in the stomach and lower abdomen, and nausea may result.

Lead poisoning can result in kidney damage. The kidneys perform the important role of processing the body's waste products. Lead poisoning causes the kidneys to become diseased and unable to function properly. Lead poisoning can also result in damage to the liver. When this happens in humans, *jaundice*, a liver disease that results in yellowing of the skin, may occur.

The nervous system can be affected during lead poisoning. The nervous system is the important communication and control system of the body. It consists of the brain, the spinal cord, and the nerves of the body. Nerves send impulses between the brain and muscles. Lead can affect nerve tissue and interfere with nerve impulses to create a wide variety of symptoms ranging from drowsiness to epileptic seizures. If lead exposure continues, muscles will often become paralyzed. The optic nerve in the eye may be damaged and blindness could result. The damage caused by lead can result in the early death of an individual, or result in some form of permanent injury.

What are the alternatives to lead?

While lead will probably continue to play an important role in our society, alternatives are possible for some uses. In gasoline, for example, the purpose that lead serves in gasoline engines can be achieved without lead at little extra cost. If you notice the pumps at gas stations you will see unleaded varieties of gas available for only a few cents more per gallon than "regular" leaded gasoline. Also, steel can replace lead in shotgun shells, reducing the number of cases of waterfowl poisoning. Substitutes can replace lead in paints and solder, too. We should be especially concerned about finding substitutes for uses that bring lead into contact with our food supply.

A case study

In 1967 two sisters, ages 2 and 3, were admitted to a children's hospital in England. They were having convulsions (violent shaking of the body) and their condition worsened until they died a few days later. At the same time, several animals in the neighborhood where the two sisters lived also developed convulsions and died. This coincidence led health officials to investigate the area. A survey of 60 persons revealed

five children and two adults had lead poisoning. These cases of lead poisoning were apparently caused by inhaling fumes from the burning of lead-storage batteries nearby. The airborne lead also settled on and contaminated food eaten by children in the neighborhood.

This case study shows the need for very careful handling of lead. If the people who were burning the batteries had realized how dangerous lead could be, the death of the two girls could have been avoided.

What Is Mercury?

Mercury, in its elemental state, is a silvery liquid metal about 13-1/2 times heavier than water. It is the only metal that occurs in liquid form at ordinary temperatures and is sometimes called "quick-silver." It has a high vapor pressure, which means it evaporates easily. It occurs in several different chemical states and its toxicity depends very much on the particular state it is in.

Elemental mercury, in the liquid state, is not very toxic if swallowed but can be very toxic if it is inhaled while in the vapor state. Since mercury evaporates easily, inhalation of its vapor may occur during handling. Mercury can also be bonded to carbon atoms and this form is quite toxic. When combined with carbon, metals are said to be in the "organic" state. Organic mercury is capable of easily penetrating biological *membranes*, such as the skin, and this property contributes to its poisonous character.

How is mercury used?

Mercury, like lead, has been known about and used by man for more than 2,000 years. In early human history, mercury was used in religious ceremonies. It has also been used in medical ointments and cosmetics. Although we now know that mercury is very toxic, it was

FOCUS: *Ecosystems and food webs*

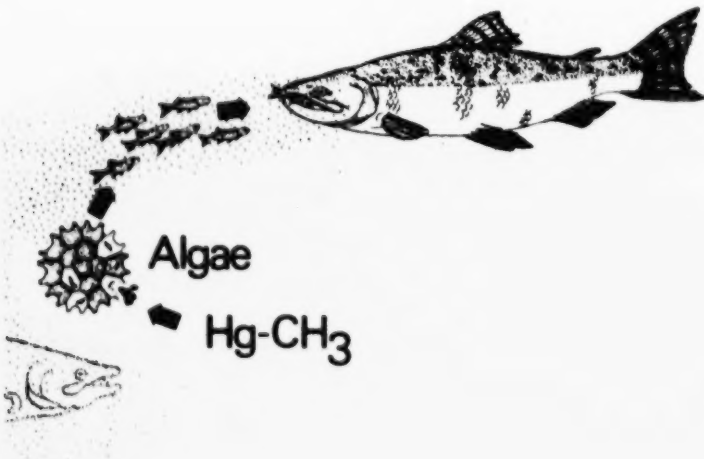
We can look at the natural world from many different perspectives, with each perspective providing us with different kinds of information. We can, for instance, look at the biosphere and try to discover how nutrients or other materials are transported around the globe, or we can look through a microscope to determine the structure of a single cell. A unit of study between these two extremes is the ecosystem. An ecosystem consists of all the different organisms in an area together with the physical environment they inhabit.

Ecosystems are not all the same size. A small pond is an ecosystem, and so is a large prairie. The important quality of an ecosystem is that it contains several different kinds of organisms that interact with each other. An ecosystem is usually contained within some form of boundary, such as the shoreline in the case of a lake ecosystem.

Every ecosystem has a source of energy and for most the source is the sun. The sun's energy is captured and stored by green plants. These plants then provide food (energy) for "herbivores," such as rabbits or grasshoppers. Herbivores, in turn, are consumed by "carnivores" such as hawks or foxes. The series of organisms through which energy passes is called a "food chain." Food chains are usually interconnected with one another in complex patterns. These patterns are called "food webs," and are key parts of ecosystems.

Food webs are usually delicately balanced and can be easily altered by man. The introduction of a pollutant can severely affect some food webs. For instance, a pollutant like mercury might be present in fairly small concentrations in soil, but when it is taken up by plants it becomes more concentrated. Since herbivores eat many plants, the mercury is concentrated

even more in their bodies. And since carnivores eat many herbivores, large amounts of the pollutant can "accumulate" in the carnivores. The process of concentrating greater and greater residues of chemicals from soil to plants to herbivores to carnivores is called "biomagnification." Biomagnification processes of pollutants can severely affect carnivores at the top of the food chains.



once thought to be a cure for many illnesses. However, these "cures" often proved to be far worse than the illness they were intended to treat and probably resulted in the deaths of many people.

Another use of mercury caused much suffering in workers associated with the hat-making industry. The treatment of rabbit fur with mercuric nitrate, to convert the fur to felt for hat-making, caused mercury poisoning in many hat-makers. Mercury poisoning is known to result in brain damage. The character of the Mad Hatter in Lewis Carroll's *Alice in Wonderland* is based on this fact. In 1941, the United States Surgeon General banned the use of mercury in the hat-making process.

Mercury has many uses today. It is used in thermometers, barometers, mercury-vapor lamps, electrical switches, paints, batteries, catalysts (which speed up chemical reactions), and in the production of chlorine. Its use in the production of chlorine is important because of the many uses we have for chlorine, including purification of the water we drink, treatment of swimming pool water, and cleaning clothes. Organic mercury is used in agriculture because of its ability to slow the growth of crop-destroying fungi.

Mercury dissolves many other metals. The resulting solutions are called "amalgams." In the refining of gold and silver, mercury dissolves the precious metals out of ores. When the amalgam is heated, mercury is driven off and the gold or silver is left in a pure state. Amalgams are also used in mirror coatings and dental fillings.

Why is mercury a problem?

Because mercury has many uses, it also has many opportunities to contaminate our food, air, and water. Mercury, and mercury-containing compounds, enter the environment in large amounts each year and can disturb natural systems. There are several major sources of environmental contamination: incineration of municipal wastes, coal,

and petroleum; the production of asphalt; mercury-containing disinfectants that get washed down drains and can end up in lakes and streams; evaporation of mercury during handling; and mercury-containing pesticides that find their way into rivers and streams. Mercury used in the manufacture of plastics may be dumped into bodies of water, as was done in Minamata Bay, Japan.

Seeds treated with mercury to control fungal growth have been mistakenly fed to livestock. The mercury-contaminated meat was then eaten by humans and resulted in brain damage. A few years ago, in Iraq, nearly 500 deaths resulted when bread, made with mercury-treated grain, was eaten by humans. Mercury-treated seeds spread in fields may also be consumed by wild birds causing illness and death.

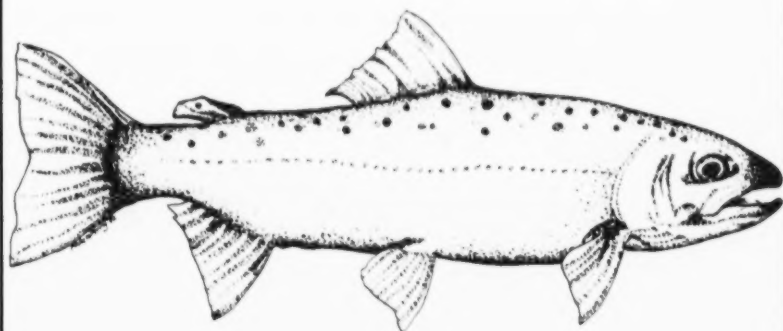
In the food web, mercury becomes more concentrated as it is taken up by various organisms. In an aquatic environment, for instance, mercury can be absorbed by plankton, which are then consumed by fish. In addition, fish take up mercury through their gills.



Mercury is used in the chemical production of chlorine and can be a significant waste by-product.

FOCUS: *Minamata—An important lesson about mercury*

A case of human mercury poisoning, which occurred about twenty years ago, taught the world an important lesson about the danger of mercury. A large plastics plant, located near Minamata Bay in Japan, used a mercury-containing compound in a reaction to produce vinyl chloride, a common plastic material. The left-over mercury was dumped into Minamata Bay with other wastes from the plant. Though the mercury was in its less-toxic inorganic state when dumped, microorganisms at the bottom of the bay converted the mercury into its organic form. The organic mercury then entered into the tissue of fish in Minamata Bay. The fish were then consumed by people living in the area. The contaminated fish caused an outbreak of poisoning, disabling more than 100 people and killing dozens more. Mothers who had eaten the contaminated fish gave birth to infants with permanent symptoms of mercury poisoning. In memory of this incident, mercury poisoning is sometimes called Minamata Disease.



Fish that breathe faster and eat more than other species of fish, such as the tuna, concentrate more mercury in their bodies during their lifetime. Mercury accumulates in fish, and generally, the older the fish, the greater is the mercury concentration in its body. Birds that eat fish concentrate even more mercury in their bodies. Whales and seals, which eat plankton and fish, respectively, have also been found to contain high levels of mercury.

What are the effects of mercury in organisms?

Mercury can be absorbed through the stomach, the lungs or the skin. Organic mercury compounds are particularly dangerous because they are more readily absorbed than inorganic ("not" organic) forms and are retained in the body longer. Organic mercury easily penetrates biological membranes and becomes distributed throughout the body. It circulates in the blood and slowly enters the brain. In the brain, it destroys cells that control coordination and other body functions.

The first symptoms of organic mercury poisoning in humans are numbness in the fingers, lips and tongue. Speech becomes slurred, walking uncoordinated, and swallowing difficult. Deafness, blurred vision, and reduced field of vision may follow. If the exposure to mercury ceases, the symptoms may gradually disappear.

The body's ability to eliminate mercury is limited and, therefore, mercury is a "cumulative" poison. A *cumulative poison* is one that builds up in the body over long periods of time. There is reduced elimination of this heavy metal because of the high attraction between mercury and cell tissue. In addition, the kidneys have difficulty in excreting mercury.

Too little is known about the effects of mercury in the environment, but research in this area is continuing. Because the consequences of contamination are difficult to predict, incidents like the outbreak of Minamata disease should prompt us to be very cautious about our continued use of mercury.

Summing Up

Lead is an abundant heavy metal and is relatively easy to obtain. It is used in batteries, gasoline, pesticides, paints, solder, pipes, and other places where resistance to corrosion is required. Most of the lead taken up by people and wildlife is stored in bone tissue. Lead can affect red blood cells by reducing their ability to carry oxygen and shortening their life span. Lead may also damage nerve tissue, which can result in brain disease. Lead exposure of young children is very important because of a child's susceptibility to lead poisoning.

Mercury occurs in several different forms. Organic mercury is more dangerous than the inorganic form because it is more easily absorbed by organisms. Inorganic mercury can be converted to organic forms by micro-organisms, as was the case at Minamata Bay, Japan.

Mercury is used in the production of chlorine. It is also used as a catalyst in the production of some plastics. Industrial processes, such as the production of chlorine and plastics, are responsible for most of the environmental damage resulting from mercury. The body has a limited ability to eliminate mercury. It is a cumulative poison and is known to cause brain damage.

Questions for Review

1. What is a trace metal? Are lead and mercury trace metals?
2. What is the largest use of lead? What use is most damaging to the environment?
3. How are children in poor neighborhoods often exposed to lead?
4. How are waterfowl exposed to lead?
5. Why does lead affect muscle control?
6. What is organic mercury?
7. Why is mercury used in agriculture?
8. How did mercury get from a plastics plant into humans at Minamata Bay, Japan?
9. What is a cumulative poison?
10. How does mercury affect the brain?



3 Industrial Chemicals: Are They Always Safe?

Synthetic industrial chemicals have contributed to longer and more pleasant lives for humans. *Synthetic* chemicals have made the manufacturing of many products for people faster, cleaner, and more efficient. Some products made from synthetic chemicals are cheaper

and longer-lasting than similar natural products. Without them, our modern society would be very different. But along with these benefits come risks to health and safety wherever dangerous chemicals are used.

Environmental pollution from industrial chemicals can occur through carelessness and accidents when the chemicals are made, transported, used or disposed of. Some companies bury their chemical wastes in *landfills* or simply dump them into rivers, lakes or oceans. This practice allows toxic industrial chemicals to contaminate the water and soil, which can cause health hazards for both humans and wildlife. Many of the most serious problems occur when we use a chemical before realizing it can have toxic effects in humans or in the environment.

Industrial chemicals occur as solids, liquids and gases. Some chemicals can burn your eyes and skin; others can irritate your lungs and make it hard to breathe. Still other chemicals can make you feel faint or sick to your stomach. Serious consequences to human health caused by industrial chemicals include serious diseases involving the major organs such as the heart, lungs, kidneys or liver. In particular, increased risk of cancer in people is thought to be associated with high or prolonged exposure to some industrial chemicals. It should be realized, however, that many other factors besides chemical exposure appear to contribute to cancer risk. Our diet, life style, genetics or family history as well as exposure to toxic chemicals, all contribute to the possibility that a person may develop cancer.

Regulations have been passed by federal and state governments to control chemical contamination of the environment. These regulations require proper labeling of chemical containers, safe use of chemicals, and proper disposal of wastes. But many chemicals have already found their way into the air, water and soil and are beyond the scope of regulations. We can only study where they go in the environment and try to prevent damage to humans and wildlife.

To illustrate the environmental health problems associated with industrial chemicals, the rest of this chapter will explain the effects of two examples: PCBs and vinyl chloride.

What Are PCBs?

PCBs are a group of chemicals known as polychlorinated biphenyls. PCBs can vary in form, occurring as colorless liquids, sticky resins or white powders, depending on the intended use. These chemicals are resistant to fire and do not conduct electricity very well, which makes them valuable for many industrial purposes.

How are PCBs used?

Before production of PCB compounds was banned in the United States in 1979, they were used in a variety of products, including paints, plastics and adhesives (gluelike substances). Before the chemicals were banned, PCBs were primarily used in electrical transformers and capacitors as insulation fluids. Much of this equipment that contains PCBs is still in use today.

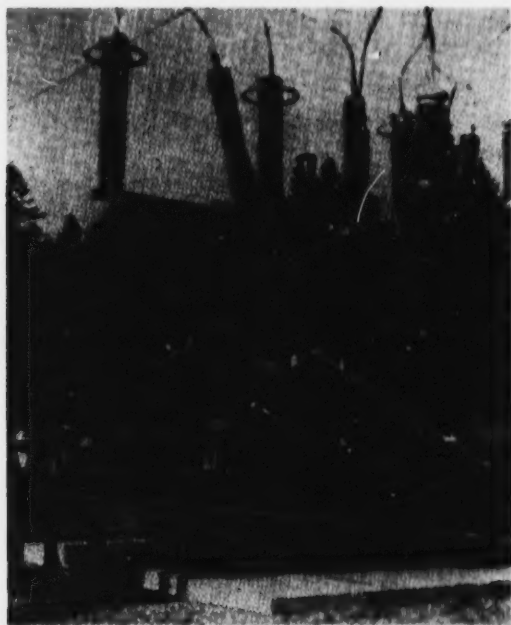
What are the dangers of PCBs?

PCB production was banned because these compounds are highly toxic to wildlife and humans. More than half of the 1.4 billion pounds produced in the United States since 1929 was released into the environment and now contaminates our air, water, and soil. Rainwater can wash PCBs out of disposal areas in dumps and landfills allowing toxic residues to end up in our lakes and rivers. Landfills are places where garbage and other waste materials such as PCBs, are placed in trenches and covered with soil. Some PCB waste has been dumped directly into our nation's waterways, as well.

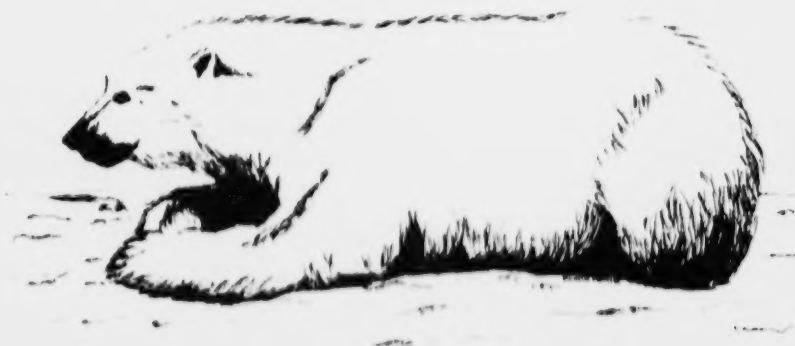
Like some of the pesticides mentioned earlier, PCBs don't break down very rapidly in the environment and thus retain their toxic characteristics. They tend to remain in the air, water and soil for long periods of time, and cause long-term exposure problems to both humans

and wildlife. Many of the products that contain PCBs last for more than 20 years. Even after these products are thrown away, they will continue to cause PCB contamination.

Since long-term exposure to toxic chemicals is often associated with an increased risk of cancer, scientists are concerned about possible health effects resulting from PCB exposure. PCBs can travel long distances in contaminated air and water—far from the places where they were originally used. PCB residues in animals are distributed worldwide; they occur in Arctic polar bears, New York chickens, Great Lakes fish, human blood and human mother's milk.



Transformers, like this one at an electrical power substation, may contain PCBs.



What are the effects on wildlife?

PCBs can be very toxic to wildlife species. Animals concentrate PCB compounds in their kidneys, liver, brain, muscles, and especially in their fat tissue. They can cause damage to the heart, kidney, and may cause liver *lesions*. PCBs can cause reproductive failure in both birds and mammals. Mink are extremely susceptible to reproductive failure if exposed to PCBs. PCBs can also cause changes in animal behavior. In some bird species, parent birds exposed to PCBs will lose interest in their eggs. If this happens, the developing embryos in the eggs may die due to the lack of parental warmth and protection.

Fish species are among the animals most susceptible to accumulating PCBs in their bodies—especially lake trout and Coho salmon. Fish, like lake trout, eat the smaller organisms contaminated with PCBs, such as minnows. Lake trout that are contaminated with PCBs are then eaten by fish-eating birds and mammals and PCBs are passed up the food chain. High and possibly dangerous levels of PCBs have been found in the flesh of fish in the Great Lakes. These fish are also an important food source for humans.

FOCUS: *Cancer—can chemicals cause it?*

Cancer is one of the most common causes of death in the United States today, second only to heart disease, and it is probably more feared than any other disease. Much is still not known about cancer and intensive research is currently underway to learn more about it. Many medical scientists think that some human cancers result from exposure to toxic chemicals in the environment. For instance, toxic organic chemicals inhaled when people smoke cigarettes are thought to create a higher risk of lung cancer among cigarette smokers.

A cancer, or "malignant" tumor, is a rapidly growing mass of abnormal cells. These cells grow and divide uncontrollably, invading and causing disease in normal tissue. It is thought that the mechanisms that control cell growth are impaired in some way, allowing these cancerous cells to grow out of control. Some environmental chemicals may damage genetic material in cells, allowing cancers to develop.

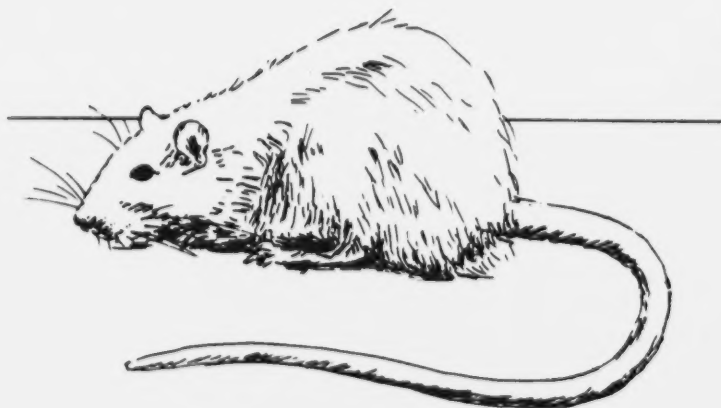
People may be exposed to carcinogens (cancer-causing chemicals) in their water supplies, their cosmetics, the fish they eat, the disposal dumps in their neighborhoods, or in the air they breathe. Many people have jobs that force them to work with carcinogens or suspected carcinogens.

Many new chemicals are brought into use every year. A major problem in controlling cancer is discovering if any of these new chemicals are carcinogens, and then controlling their use if they are found to be carcinogenic. Lack of knowledge about carcinogens makes it very difficult to implement these controls.

Studying rats has proven to be an effective way to identify carcinogens, but this method is not perfect. One problem with testing rats is that we can not be completely sure that the chemical will have the same effect in humans that it has in rats.

Until better techniques become available, scientists who study cancer will use animals such as rats as models to test the ability of chemicals to cause cancer. It is their hope to be able to detect carcinogens in these laboratory animals first so people can be protected from the hazards these chemicals present to human health.

Much needs to be learned about how cancers develop in our bodies. However, it appears that chemical exposure can be at least one cause of cancer.



Rats are used extensively for testing potential chemical carcinogens.

What about people?

In 1968, an accident involving PCBs occurred in Yusho, Japan. In a factory where cooking oil was made, the oil became contaminated with PCBs. When this oil was eaten by people, five of them died and thousands became very sick. Symptoms of this PCB poisoning, called "Yusho disease", often included chloracne (a serious skin problem), nausea, vomiting, abdominal pain, swelling and fatigue.

Another problem with PCB exposure is that the chemical can be passed from mothers to breast-fed babies. Since human milk has a high concentration of fat and because PCBs are *soluble* in fats, PCBs can readily build up in milk and be passed to the baby. In this way, breast-fed babies can receive more than fifty times the concentration of PCBs found in the food eaten by their mothers. In Japan, the babies born after exposure of their mother to PCBs, often had discolored skin, discharge from the eyes, and they tended to be smaller than normal, healthy babies.

PCBs have been identified as being liver carcinogens in laboratory test animals. For such reasons, human exposure to these substances could be important in terms of cancer risk or other health problems previously discussed. Therefore, it is important that human exposure patterns to PCBs be carefully *monitored*.

What are the alternatives to PCBs?

Scientists and government agencies are now working together to find solutions to the PCB problem. Substitute compounds, less toxic to the environment, can be used instead of PCBs. PCB contamination can be monitored to help reduce future exposure. Proper disposal of PCB wastes is now required. The compounds are chemically treated or burned at high temperature to prevent harmful residues from entering into the environment.

PCBs are a very real health problem and can be harmful both to people and the environment. They can cause serious diseases in wildlife and humans. People can be exposed to PCBs in the food they eat, the water they drink and also at the places they work. PCBs will continue to be a problem until contamination can be prevented and all wastes containing PCBs can be properly disposed of.

What Is Vinyl Chloride?

Vinyl chloride is a colorless substance, and can be either a liquid or a gas. The vinyl chloride gas is made from petrochemicals (chemicals made from petroleum) and chlorine. It is the primary ingredient in the second-most widely used plastic in the United States, polyvinyl chloride.

How is vinyl chloride used?

After vinyl chloride is chemically changed into polyvinyl chloride, it is manufactured into a large variety of products. The major uses for polyvinyl chloride include: building products, home furnishings, automobile upholstery, phonograph records, clothing (baby pants and raingear), and packaging for food and other products.

What is the danger?

In 1976, the Environmental Protection Agency classified vinyl chloride as the fourth most hazardous air pollutant in the United States. It is a potent cancer-causing agent in humans even with little exposure. Usually, people are only exposed to high levels of vinyl chloride if they work with it or near it, but exposure can also occur from vinyl chloride gas leaks. The vinyl chloride gas can leak from trucks that transport it and from the manufacturing plants where vinyl chloride or polyvinyl

FOCUS: *Love Canal—Chemical wastes out of control*

In 1978, President Jimmy Carter declared a national emergency in an area called Love Canal, in Niagara Falls, New York. He did this because the area was identified as being severely contaminated with poisonous industrial chemicals. Many people living in the area had been exposed to the chemicals and showed symptoms of poisoning. By the end of 1978, 238 families were forced to leave their homes and move away from Love Canal. How did this situation come about?

In 1947, Hooker Chemical Company bought Love Canal to use as a place to bury the wastes from some of its chemical production processes. The company dumped its toxic wastes into the empty canal until 1954. It then covered the canal with soil and donated it to the Niagara Falls Board of Education. A school was later built on top of the buried wastes.

In 1977, people began to discover that chemical waste was leaking out of the ground. Rainwater had settled into the canal causing the chemicals to float to the surface and overflow. Before long, the chemicals migrated into the soil of the

surrounding neighborhoods. Pools of chemicals began to appear in backyards and basements of area residents.

Area residents experienced rashes, bad headaches, breathing problems, infections, and other symptoms sometimes found in people excessively exposed to hazardous chemicals. These symptoms occurred at approximately the same time as surface pools of chemicals appeared. A scientific study was undertaken to find out what the chemicals were. The people were shocked to find out that they were being exposed to a wide variety of substances including DDT, PCBs, and C-56 (one of the most deadly chemicals known to man).

The Love Canal incident is an example of a situation where people were directly affected by the dumping of hazardous waste. Dump sites for chemical wastes must be chosen and prepared extremely carefully, and they should be watched for many years to detect leakage. Houses or public buildings should not be built on or adjacent to such a site.

chloride are made. Since most of these plants are located in highly populated areas like New Jersey, California and Ohio, people living near a plant (within five miles) can be exposed to high amounts of vinyl chloride from contaminated air and water.

People who frequently use polyvinyl chloride products are exposed to smaller but still possibly harmful amounts of vinyl chloride. Since the manufacturing process used to change vinyl chloride to polyvinyl chloride is not perfect, some of the vinyl chloride gas remains trapped in the finished polyvinyl chloride product. Therefore, this gas can gradually leak out during use of the product and also after the product is disposed of, causing contamination of the environment. This leaking problem with vinyl chloride gas can be especially important when polyvinyl chloride is used for food and beverage containers. Leaking vinyl chloride gas can then enter into the food product that might be later consumed by people. Although it is unlikely that anyone has ever been harmed by vinyl chloride exposure from packaged foods, it is possible that vinyl chloride can act together with other factors to increase the risk of developing cancer 20 or 30 years later.

What are the effects of vinyl chloride on people?

At high levels, vinyl chloride acts as a powerful *anesthetic* and causes dizziness, drowsiness and even unconsciousness in people. After a continuous long exposure (one to three and one-half years) in humans, vinyl chloride can cause deafness, vision problems, circulation disorders, and bone deformities. Some other human ailments associated with vinyl chloride poisoning are lung disease, liver disorders and stomach problems. Vinyl chloride can also cause birth defects.

The potent carcinogenic properties of vinyl chloride were discovered in 1974 when three workers in a polyvinyl chloride plant died from a rare form of liver cancer, angiosarcoma. By 1976, thirty-eight more cases of this type of cancer were identified and confirmed among

vinyl chloride workers by the National Cancer Institute. Although many people, perhaps thousands, were occupationally exposed to vinyl chloride, there is evidence that exposed workers did experience higher incidence of liver cancer than would be expected in the general human population not directly working with vinyl chloride.

What are the alternatives?

Regulations now protect workers, consumers and those people who work in or live near vinyl chloride or polyvinyl chloride plants. Other types of plastic have been substituted in products where vinyl chloride exposure can result in human health problems. Polyvinyl chloride use can be lowered by reducing our use of plastics. By reducing waste, encouraging recycling, and using products that are well-made and durable, we can greatly reduce our consumption of polyvinyl chloride, as well as curtail the exposure of humans and wildlife to these substances.

Summing Up

Thousands of chemicals are used in industry. When used incorrectly or inappropriately, many of them are considered health hazards. People and wildlife are exposed to these chemicals in contaminated air, water and food. People may be exposed to chemicals where they work, as well.

PCBs and vinyl chloride are both hazardous chemicals. They have been found to be contaminants in the environment, and have caused serious health problems in humans and wildlife. Regulations now control the release of these chemicals into the environment, but the amount that has already been released may continue to cause problems.

Love Canal is an extreme example of the danger posed by toxic industrial chemicals, but it is not the only one. Other landfills leaking dangerous chemicals can be found all across the United States. As investigations continue, more illegal toxic waste landfills will probably be found and then, it is hoped, cleaned up.

Industrial chemicals can be beneficial but they can also be hazardous to both the health of humans and wildlife. Careful use and proper disposal of industrial chemicals are important to prevent chemical pollution of the air, water and soil and the resulting environmental damage.

Questions for Review

1. How and where are humans and wildlife exposed to hazardous industrial chemicals?
2. Where are PCBs used and what are they used for?
3. Why are industrial chemicals necessary?
4. What kind of food products can be contaminated with PCBs?
5. Why should landfills be monitored?
6. How can vinyl chloride contaminate food?
7. What serious disease is associated with exposure to vinyl chloride?
8. Why did scientists suspect chemical poisoning at Love Canal?
9. What are some alternatives and solutions to the problem of hazardous chemical pollution?
10. What animals appear to be most affected by PCB poisoning?



4 Chemical Hazards Around the Home

You may not realize it, but many household chemicals can be quite toxic to you. The chemicals in these products can harm wildlife as well. Most of the dangerous substances in the home are found in various kinds of cleaners, solvents and products used for automotive care. The greatest potential for harm occurs when these products are used incorrectly. This chapter will discuss the dangers and effects of these household products.

What are the dangers of disinfectant chemicals?

Toilet bowl cleaners are used to dissolve mineral build-up and organic stains. They are made of sodium acid sulfate and are highly acidic when mixed with water. Liquid toilet bowl cleaners contain hydrochloric acid (HCl) or phosphoric acid (H_3PO_4). Since human tissues, such as skin, are organic in nature, they can be harmed by these products. Inhaling the vapors of concentrated HCl causes irritation in the lungs and throat. Acidic cleansers can also burn the skin. If the cleansers are swallowed, the stomach, throat and small intestine can be especially damaged. Severe stomach pain and possibly death may result. The estimated *lethal dose* (amount that can cause death) of these acids in people is about 30 grams (approximately one ounce).

What are alternatives to disinfectant chemicals?

For safer cleaning, ammonia or baking soda can be used in place of toilet bowl cleaners. If the bowl is not stained, ammonia used at the correct strength is a very good cleaner. If stains are present, the bowl can be scrubbed with a sponge and a paste of baking soda. These alternatives can also save money.

What problems do oven cleaners pose?

There are four types of oven cleaners: aerosol sprays, liquids, pastes, and powders; all of them contain lye (sodium potassium hydroxide). They are used to remove baked on organic materials (grease and food) in ovens. Lye is a base or alkaline (the opposite of an acid). Like acids, bases can harm organic material including human skin, lungs, and eyes.

Aerosol oven cleaners are the most dangerous of the four types mentioned above; they are also the most popular. When sprayed, aerosol oven cleaners release tiny droplets of lye and the other powerful

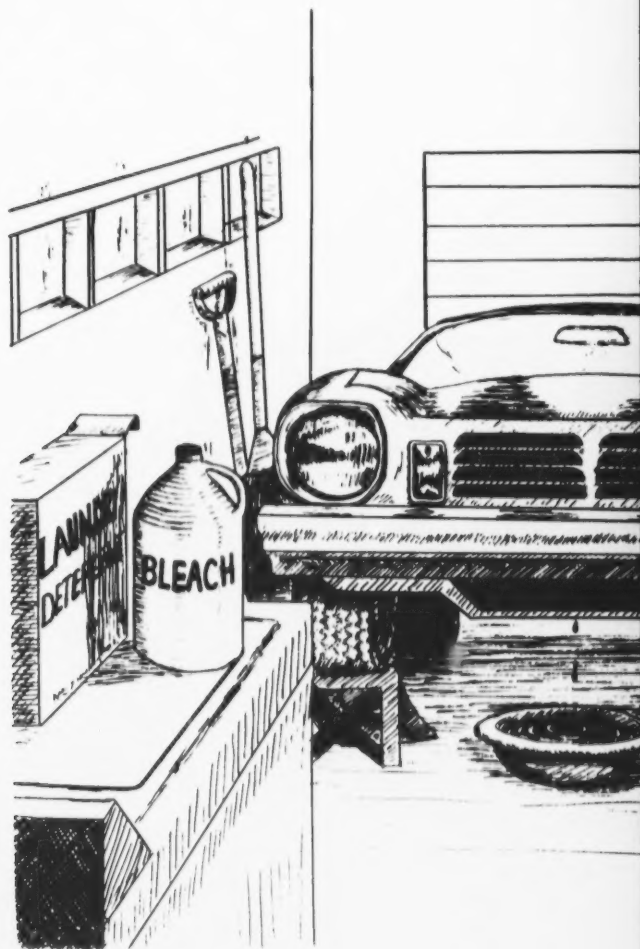
chemicals into the air. These substances can land on people's skin and eyes, and possibly be inhaled to contact sensitive lung tissues. Liquids are the next most hazardous of the oven cleaning materials. They can spill, flow easily and react immediately with human skin. Pastes are less dangerous because they don't enter the air and can't spill, but they can still harm people's skin. Powdered cleaners are probably the safest type but they are not often used. The powder releases ammonia when mixed with water. Ammonia fumes can irritate the lungs but ammonia has a strong odor, which is difficult to tolerate. Because of the odor, the user is less likely to allow the fumes to become too concentrated and, thus, possibly harmful.

FOCUS: *First aid for acids and bases*

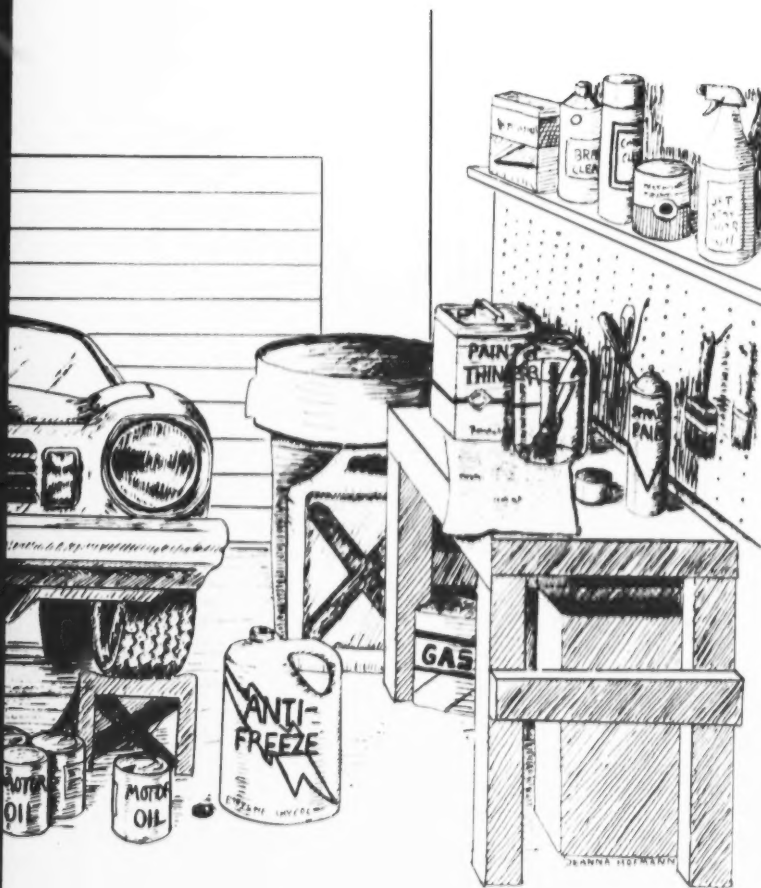
When acidic or basic chemicals splash into your eyes, severe eye damage can occur. Symptoms can include inflammation of the mucous membrane lining the eye and eyelid and destruction of the cornea. Basic chemicals such as lye are more damaging to eye tissue than acids because they penetrate the eye much more quickly. Prompt treatment of eyes exposed to acids and bases is very important. Failure to do so may result in blindness. If acids or bases get into a person's eyes, they should be flushed with water immediately and continuously for at least five minutes for acids and fifteen minutes for bases. The injured person should then be taken to a clinic or medical center for further treatment.

If bases or acids splash on your skin, rinse immediately with lots of cool running water. You can tell when a base is completely washed off because the skin will not feel slick. If a person swallows an acid or base, *DO NOT* induce vomiting. Make the person drink lots of water or milk. Get them to a hospital immediately. If you have questions about what to do, call a poison control center or if that isn't possible call your family doctor.

A wide variety of potentially toxic products can be found in your own home.



Toxic Substances in the Environment



Household Chemicals

What are alternatives to toxic oven cleaners?

After cooking in the oven, cleaning up the spill soon after it has cooled is the easiest way to keep an oven clean. A paste of baking soda can be used to scrub off tough spots. To clean a really dirty oven put 1/4 cup ammonia in 1/2–1 gallon hot water in a glass bowl (do not use a metal pan). Do not mix the ammonia solution any stronger since strong ammonia fumes can be dangerous. Set the bowl containing the ammonia solution in a cool oven, close the door and leave it overnight. Do not heat the oven. The next morning, remove the bowl and wipe out the oven with a warm, wet cloth using baking soda paste as needed on tough spots.

Can drain cleaners be dangerous?

Drain cleaners, like oven cleaners, contain mostly lye. They come in liquid and crystal forms. Their purpose is to attack organic materials; grease, food wastes and hair that clog drains. Liquid drain cleaners begin dissolving organic material on contact and can be very dangerous to skin and can damage the *gastrointestinal* system if swallowed. Dry crystals can easily be brushed off if spilled on the skin, but may splatter when mixed with liquids. Also if the drain cleaner doesn't work, the drain will still be clogged and, in addition, will be full of a dangerous chemical.

What are alternatives to drain cleaners?

The best remedy for clogged drains is to keep food, grease and hair out of them. For a sink that drains slowly, pour boiling water down the drain and 1/4–1/2 cup washing soda (borax), wait a minute, then flush the drain again with boiling water. If the drain still remains clogged, use a plunger (plumber's helper) or a plumber's snake.

What about laundry products?

Today, detergents are thought of as *synthetic* soaps. Detergents contain many ingredients including water soluble and oil-soluble chemical groups that actually do the cleaning. A commonly used chemical group is LAS (linear alkylate sulfonate), but there are some problems with using this compound. Apparently, LAS can accumulate in water with a low oxygen content. In this situation, a concentration of LAS as low as 1 milligram per liter may be enough to kill oysters. Prolonged exposure to LAS residues in clothing is also suspected to be hazardous to human health. Other chemicals in detergents include perfumes to make clothes smell clean. These perfumes may cause *allergic* reactions such as asthma, hay fever, and dermatitis (rashes). Also, enzymes that break down protein, carbohydrate grime, soil, and stains are present in detergents.

Some of the chemicals used in detergents are highly basic (pH 10.5-12.0; pH 7 is neutral). Just a few grains of detergent accidentally rubbed into the eye and left untreated can cause severe eye damage. Eating or drinking detergent will severely burn and damage throat and stomach tissue. If detergents are swallowed, the primary symptom is burning pain from the mouth to the stomach. If the poisoning is very serious a person may die within 48 to 72 hours. Other effects from detergents are increased cases of dermatitis, flu-like illnesses, and asthmatic conditions from breathing enzyme detergent dust.

What is dangerous about bleaches?

Bleaches (usually chemicals containing sodium hypochlorite) are used to make white clothes look whiter by breaking down color-containing substances. Bleaches also kill germs. Bleaches are basic (alkaline) and affect human tissue just like other bases do; they burn the

skin and eyes and irritate the respiratory tract. A common warning on bleach and detergent labels is:

DANGER: In case of eye contact, flush with water for 15 minutes. Get prompt medical attention. Keep out of reach of children.

What are alternatives to laundry chemicals?

Detergents can be replaced with soap. For areas with "hard water," washing soda will soften the water when cleaning clothes. For further brightening of white clothes, borax (washing soda) can replace bleach. Borax doesn't damage fabrics like bleach does and it is safe to use with all fabrics and all colors.

Can solvents be hazardous?

A solvent is a substance that can dissolve another substance. The most common solvent is water. Since it can dissolve so many things, water is known as the universal solvent. Like water, solvents are usually liquid.

Turpentine, depentine, and pine oil are solvents commonly used in oil-based paints. Although solvents may not be as toxic as some other chemicals mentioned in this book, such as parathion, they can still have harmful effects and should be used carefully. Alcohols, including methanol, de-natured ethanol or propanol are also solvents. These alcohol solvents are often confused with the alcohol that people drink but, if these alcohols are swallowed, very serious complications may result. The liver and kidneys could be damaged and the person may die. Most alcohol solvents irritate the eyes and upper respiratory tract: some can cause permanent eye damage.

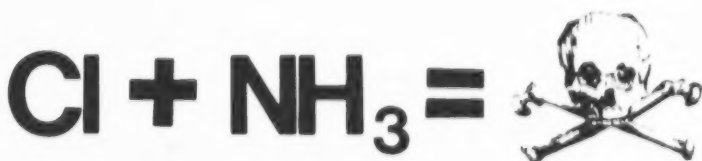
In general, solvents can cause eye damage and inhalation of the fumes results in light-headedness, headaches, dizziness, nausea, weakness and drowsiness. Skin contact may result in rashes and inflammation.

FOCUS: *Some chemicals don't mix.*

Mixing various types of household cleansers is often done and can be very dangerous. The fumes resulting from the chemical reaction of these mixtures can be harmful to people, especially when used in poorly-ventilated bathrooms and kitchens.

In 1975, a 68 year old woman in Portland, Maine mixed ammonia with chlorine bleach to wash off eggs splattered on her house at Halloween. After cleaning, she brought the bucket back into her house and, inside, the fumes from the mixture poisoned her and she died. The person who tried to revive her was also overcome by the fumes and also died. The cause of the deaths of these two people was chloramine gas formed from the mixture of ammonia and chlorine.

Not only does the combination of ammonia and chlorine produce a dangerous gas, mixing acid-type (solid) toilet bowl cleansers with vinegar, lye, ammonia, bleach or other alkaline compounds can also produce deadly fumes (gases).



The liver is severely affected by solvents. The liver removes poisonous chemicals from the blood. When harmful chemicals enter the blood through ingestion, breathing or skin contact, the liver can usually break them down into less toxic substances. The kidneys then filter out these chemicals and pass them out of the body in the urine. Chemicals that

are not broken down will remain in the body. These chemicals can kill cells and can seriously damage the liver. If enough liver cells die, the liver cannot function properly.

Paint removers contain a solvent called ethylene chloride. Exposure to ethylene chloride fumes for 2–3 hours, for instance, can reduce the amount of oxygen in the blood. Oxygen is carried by the blood for use by cells in our body. Those people with heart disease are particularly susceptible to oxygen stress caused by exposure to ethylene chloride.

In one case history, a retired man suffered several heart attacks after he took up the hobby of refinishing furniture. Doctors did not connect his use of a paint stripper solvent to his repeated heart attacks until after his death. This case led to research revealing the effects of solvents on people. Research indicated that these solvents can affect the body for several hours after exposure and can result in heart attacks in those persons with heart conditions.

Are there any other effects of solvents?

Solvents that evaporate into the atmosphere can add to smog conditions in cities. Studies in Los Angeles County, California, have revealed the amounts of solvents in the air and that a reduction in the use of solvents could greatly reduce the air pollution problem. Therefore, Los Angeles County has passed laws regulating the amount of solvents that can evaporate from paints to reduce this source of air pollution.

For those who wear soft contact lenses, solvents are an additional hazard. Soft contacts soak up fumes from solvents. Since the chemical is absorbed by the contact lenses, tears cannot wash them away. Thus, the solvent is held against the eye until the lenses are removed. This lengthened eye contact can cause irritation and even major eye damage.



Evaporation of toxic solvents can contribute to air pollution, adding to the smog condition seen here in this view of New York City.

What are alternatives to solvents?

Using solvents correctly and safely is the best solution for solvent-caused problems. When painting, use a water-soluble paint whenever possible. However, some water-base paints may contain other toxic chemicals so read the label and follow the directions. When doing a job that requires the use of a solvent, always read the label and be careful to work in a well-ventilated area.

Do automotive products have harmful effects?

Nearly every family in America has at least one car. The products used in the maintenance and operation of cars can be toxic. Like products used in the home, these products are not usually thought to be dangerous. However, they can be harmful to you and you should be aware of the dangers associated with their use.

Gasoline. Gasoline is highly toxic, yet many of us do not respect its potential for harm. Leaded gasoline is used to remove paints from hands and arms, and is freely splashed on garage floors and driveways to remove oil and grease stains. Gasoline contains many harmful chemicals:

- a. Ethylene dichloride and ethylene dibromide, known as scavengers, are incorporated into gasoline to remove lead oxides from the fuel system in the car. They can cause liver damage and may cause cancer in people.
- b. Anti-oxidants (amines or alkylated phenols) are added to gasoline to keep it from decomposing during storage. Some antioxidants can burn the skin and eyes.
- c. Deicers keep the small amounts of water in gasoline from freezing. The common deicers are methyl and isopropyl alcohol (see dangers of solvents).
- d. MMT is a magnesium additive found in unleaded gas. It is extremely toxic to humans and can cause many neurological (brain) disorders.

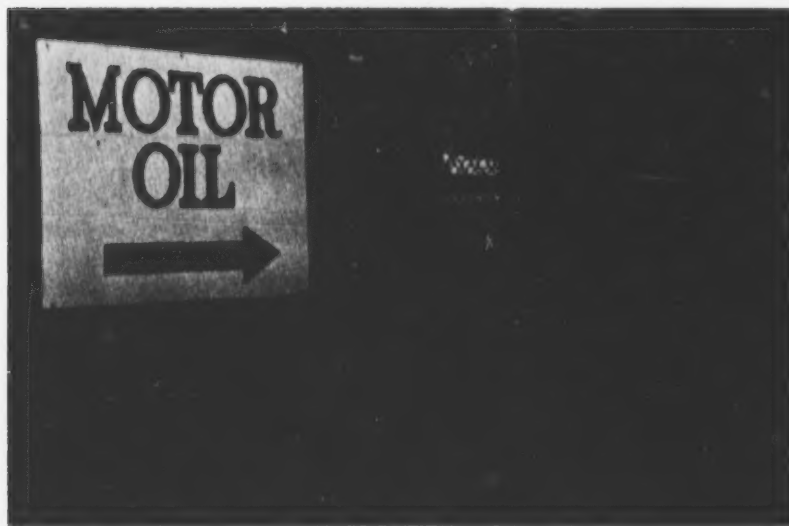
Always be very careful when handling gasoline. Never try to siphon gas by using your mouth to create a suction.

Motor Oils. Waste oil, containing additives, is a personal as well as environmental problem. The personal problem is what to do with the used oil. The environmental problems of waste oil disposal include an estimated 3.4 million pounds of barium, 4.2 million pounds of zinc, 59 million pounds of lead and 21 million pounds of phosphorous compounds dumped into the environment each year. Due to the detergent additives in newer types of oil, the traditional methods to clean up oil for reuse are not as efficient. A national oil recycling system would be helpful for dealing with this problem.

Other Auto Products. Anti-freeze (ethylene glycol) is very poisonous. It is a sweet-tasting liquid and if dumped into the gutter or driveway, pets may ingest it and die. Deicers for window-washer fluids are often alcohols, some of which can be very toxic (see solvents).

What are alternatives to automotive products?

Like solvents, the unique properties of autocare products make it difficult to find alternatives. The best means of controlling this source of pollution is to use less. This means changing our emphasis on the car as the primary means of transportation.



Recycling is an alternative for the disposal of used motor oil.

Since our society probably could never completely give up the use of cars, the products needed for car care will continue to be around. The following may help reduce their dangers:

- Don't use leaded gas in camp stoves or for cleaning up paint, oil or grease.
- Keep all auto products out of the reach of children who can't follow directions of caution on the label.
- Avoid breathing car exhaust and gasoline fumes.
- Dispose of oil correctly. Don't pour it down the drain or into any water system. Don't pour it into the storm gutters because it will end up in the nearest river or lake. Pour it around the foundation of the house to discourage termites or if an oil recycling station is available, take the used oil there.

Summing Up

The best way to avoid personal and environmental harm from the use of household chemicals is to learn about them. Find out where dangerous chemicals are in your house. With proper precautions, dispose of those no longer needed. If you are not sure how to do this, call a local poison control center. Don't use a strong toxic chemical when a milder or non-toxic chemical could be substituted. Use a little "elbow grease" instead. Most important, read and follow instructions, and pay attention to precautions.

Questions for Review

1. What kinds of products in your home might be hazardous if misused?
2. What is the major ingredient of drain and oven cleaners?
3. Why should acidic and basic solutions be used with caution?
4. What are some of the alternatives to household cleansers?
5. Why is mixing chlorine and ammonia dangerous?
6. Are the alcohols found in solvents the same as the alcohol that people drink?
7. Why is adequate ventilation important when using household chemicals?
8. Why shouldn't you use leaded gasoline to remove paint from your hands?
9. How can oil be properly disposed of?
10. Who could tell you how to dispose of toxic household chemicals?

FOCUS: *Rachel Carson—her story of the chemical threat*

"We spray our elms, and the following spring, trees are silent of robin song, not because we sprayed the robins directly but because the poison traveled, step by step, through the now familiar elm-earthworm-robin cycle."

Rachel Carson

This quotation appeared in Rachel Carson's book entitled *Silent Spring*. In the years following the publication of *Silent Spring* in 1962, the book has inspired controversy and has initiated a major change in thinking about the safety of using pesticides and other toxic chemicals. The book gained acclaim and admiration for Rachel Carson; it also brought attack from those who disagreed.

Before the publication of *Silent Spring*, DDT and other potent pesticides were often used indiscriminately and in amounts exceeding what was recommended. After extensive research into the scientific evidence and consultation with countless experts, she was convinced that DDT was upsetting the "balance of Nature." Ms. Carson was especially interested in the effects of pesticides on cells in the body and the possible relationships with cancer. In regard to pesticide use, she didn't suggest that there was no insect problem and, therefore, no need for control. Rather, she stressed the need for realistic solutions to pest problems—solutions that would not destroy us along with the insects. This she explained in the following quotation from *Silent Spring*:

"Can anyone believe it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for all life."

Rachel Carson, an experienced naturalist, had a deep appreciation for the beauty and value of nature. Trained as a marine zoologist, she worked for many years as a publications editor for the United States Fish and Wildlife Service. She was a talented author and well-known for *The Sea Around Us* and other books about the ocean and shorelines. She is said to have combined "the imagination and insight of a creative writer with a scientist's passion for fact."

Ironically, Rachel Carson died of cancer in 1964, at the age of 56. She is remembered as one of the most eloquent spokespersons for conservation in our time—a woman with a deep reverence for life.





In Conclusion

Endrin, 2-4,D, vinyl chloride, mercury, bleach—these are some of the toxic substances that you have read about in this book. They are examples of chemicals our society regularly uses, perhaps with less than adequate safety precautions. As you have read, some of these chemicals have contaminated our environment and seriously affected the health of humans and wildlife. When chemicals are used out of their proper place, or without adequate safeguards, numerous diseases may result, including cancer, heart disease and mental retardation. In the environment, chemicals such as pesticides have poisoned animals. Pesticides have killed wildlife outright or have probably caused their death indirectly by weakening them and making them more susceptible to freezing, starvation, or predation.

Since our society chooses to take advantage of the benefits chemicals offer, society must also take steps to ensure they are used safely. Methods are needed for controlling the release of toxic substances into the environment. The first task in solving this kind of problem is to learn as much as possible about the problem. Scientific study must be directed to both chemicals now in use and to chemicals that are in the development stage. People should become concerned about both the health effects of chemicals and the ways by which humans and animals become exposed to them.

Once we have gained knowledge of a chemical substance, we can make informed decisions about its use. We might decide the benefits of the use of a toxic substance do not outweigh the risks and choose not to use it at all. Or we may decide that it is acceptable to use a substance under certain specific circumstances, where it is adequately controlled and exposure to toxic levels is prevented.

Our government has written laws to regulate the use of chemicals in order to protect our health. The Toxic Substances Control Act, for instance, requires chemical manufacturers to test new chemicals for health effects before they are sold on the market. This requirement is based on the idea that it is best to learn about a potential problem from the use of a chemical before it becomes a large-scale environmental problem. Another law, the Poison Prevention Act, requires special packaging of certain household substances that may pose a hazard to children. The Safe Drinking Water Act was designed to regulate contaminant levels in the public water systems used for drinking water, and to protect underground sources of drinking water from contamination due to waste disposal activities. These laws and others help to protect us from toxic substances, but do not provide complete protection. Therefore, every person should develop an awareness of the potential dangers of chemicals they use or are exposed to.

By reading this book, you should have increased your awareness of chemical hazards. The substances discussed in this book are relatively well studied, but there are still many unanswered questions about them. In addition, there are thousands of other chemicals that

are in use in our society, and little is known about the health effects of many of them. It is hoped that the information you have learned from this book will allow you to be able to ask better questions about the chemical substances that are part of the society in which you live.

From now on, when you hear about, or read about the uses of a chemical, we hope you might ask: Yes, this chemical is useful, but is it safe? Has it been thoroughly tested? Can it cause cancer? Can it cause brain damage? What happens to it in the environment? Will it break down rapidly and completely, or will it persist for years in some toxic form? Will it contaminate food chains? If questions like these are not adequately answered, we cannot make informed decisions about a chemical's use. A balanced attitude about chemicals, always considering both benefits *and* risks, may someday be useful in helping you to make a decision that could protect not only your health, but the health of other people and the health of our environment.



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Glossary

absorb

To take up or to take in a substance. Sponges absorb water. Human skin can absorb pesticide chemicals.

accumulate

To build up, to increase. Certain pesticides and heavy metals can accumulate in the body.

acute

A response within a short period of time. Parathion is a substance that produces a rapid, harmful effect in people after they are exposed and can be described as an acute toxin.

allergy

An unfavorable body reaction upon exposure to a substance, such as sneezing, itching or rashes.

anemia

A weakened body condition related to oxygen deficiency. It can be caused by a limited supply of hemoglobin or red blood cells. Lead poisoning can result in anemia.

anesthetic

A substance capable of producing a loss of pain and sensation. People usually receive an anesthetic before a surgical operation.

aquatic

From or relating to water. Fish are aquatic organisms.

bioaccumulation

Concentration of a substance by a biological system. Clams can bioaccumulate lead from the water they live in which results in a much higher concentration of lead in their bodies than in the water.

by-products

Something produced in addition to the primary substance during a production process. Dioxin is a by-product of the production of 2,4, 5-T.

cancer

A malignant tumor or condition in which cells grow and multiply uncontrollably, invading and causing disease in healthy tissue. It occurs when mechanisms that control growth are impaired in some complex way.

carcinogen

Cancer causing substance.

carnivore

An animal that eats other animals. A flesh eater. A wolf is a carnivore.

capacitors

A device to store an electrical charge for later use.

chronic

Of a long duration such as months or years. Chronic exposure to chemicals can often lead to diseases, such as cancer.

circulatory system

Involves mainly the heart, blood, veins and arteries. This system transports food energy and oxygen to the body cells and waste products away from the cells in a constantly circulating flow of blood.

combustion

The burning of something. When gasoline burns in an internal-combustion engine, energy is released to power the car. Contaminants in gasoline, such as lead, can be liberated into the environment during this combustion process.

compound

A combination of elements. Water is a compound made from hydrogen and oxygen. The properties of a compound are different from those of the elements from which it is formed.

contaminate

To make something less pure. Adding salt to sugar contaminates it, although this is not hazardous. Also to make unfit for use, undesirable, polluted. Pesticides can contaminate water and this can be hazardous.

convulsions

An abnormal, involuntary and violent shaking of the body that is caused by severe muscle contractions. Damage to the central nervous system can cause convulsions.

corrosion

The process of wearing away gradually by chemical action. Acids can cause corrosion of metal surfaces.

cumulative poison

A poison that builds up in an organism or biological system. Though an organism may consume only small amounts of a toxic substance at a time, such as mercury, if the body cannot adequately eliminate it, the substance accumulates and could eventually cause death to the organism.

dioxin

A toxic by-product in the production process of the herbicide, 2,4, 5-T.

dose

The quantity of a substance that an organism is exposed to over a given period of time.

ecosystem

The interacting system of a biological community and its non-living environment. A lake, for instance, can be considered as an ecosystem. The sun provides the major energy input, which is captured as "food energy" through photosynthesis by a green plant, such as algae. Algae are in turn eaten by fish, passing this trapped energy up the food chain. The non-living part of the ecosystem, such as oxygen level in the water for example, is also important for the survival of many organisms including fish.

embryo

An organism in its early stages of development. Before a bird egg hatches, the developing organism inside is called an embryo.

environment

The living and non-living surroundings of an organism.

enzyme

Substances produced by organisms to promote biochemical reactions. These substances promote the break down of protein, carbohydrate, grime, soil and stains. Present in laundry detergents.

exposure

In regard to a toxic chemical, the manner in which a person is subjected to the poison (through inhalation, ingestion, or skin contact).

feces

Expelled body waste, manure, droppings.

food chain

A simpler version of a food web (see below). The chain is a flow of food energy from plants to plant-eating animals to meat-eating animals. A food chain in a lake might involve: algae → fish → fish-eating fish → human.

food web

The interconnected system of food sources, which includes plants, the animals that eat those plants, and other animals that eat the plant-consuming animals. The system is balanced so that the loss of one or more members of the web can potentially disrupt it and affect all other members of the food web.

fumes

Irritating smoke, vapor or gas.

fungi

A group of plants that don't have chlorophyll, the green pigment found in green plants. Some fungi infect and cause disease in plants or animals, others are useful in breaking down waste.

gastrointestinal

Relating to both the stomach and the intestine.

habitat

All of the environmental conditions in a specific place, which is occupied by an organism, a population or a community. For instance, a place in which an organism lives. Our homes are part of our habitat.

hazard

Anything that presents a danger. Toxic chemicals are hazardous because they have the potential to cause illness or death.

herbicide

A plant or weed poison. 2,4-D and 2,4,5-T are herbicide chemicals.

herbivore

An animal that eats plants, such as a cow or grasshopper.

hormone

Substances produced in plants and animals that stimulate the functioning of certain bodily processes, such as growth and digestion. A plant growth hormone signals the plant to grow in size.

incineration

Burning to ashes.

industrial

In regard to chemicals, having to do with a company or factory that makes chemicals or uses products that contain chemicals.

ingestion

Eating, taking substances through the mouth into the stomach.

inhalation

Breathing, taking air and any other substances that may be in the air, into the lungs.

inorganic

Lacking carbon.

insecticide

Insect poison. A chemical used to kill insects.

insulation

Material used to prevent the escape of electricity, heat, sound, etc. In cold weather, a well-insulated house is easier to heat than a poorly insulated house.

integrated pest management

The system of controlling pests which combines the use of predator insects, knowledge of pest life cycles, crop rotations, and minimal use of chemicals.

jaundice

A liver disease that results in yellowing of the skin.

landfills

A system of trash and garbage disposal in which the waste is buried between layers of soil.

lesions

An injury or disease to an organ or part of the body. Scratches are a form of skin lesions.

lethal dose

The amount of poison that results in death of an organism.

membrane

A thin, flexible outer layer of plant or animal tissue. A cell membrane protects the cell and gives it structure. It allows necessary nutrients to enter the cell, but excludes many foreign chemicals. But some foreign substances can pass through the cell membrane, such as organic mercury, and cells can be poisoned.

micro-organism

A tiny or microscopic organism.

miscarriage

Premature death and expulsion of a fetus from the uterus during pregnancy.

monitor

To study the performance, activity, or quality of a product. To watch or check on.

monoculture

The farming of one single crop, such as an entire field planted in corn.

nervous system

The system in the body that includes the brain, the spinal cord and the nerves. The brain sends impulses that travel through the spinal cord to the nerves, controlling muscle activity and messages from the five senses.

non-target organism

The organisms harmed or killed by a poison that are not intended to be exposed to it. People and birds are often non-target organisms of pesticide chemical usage.

nutrients

Substances essential for growth and development. Oxygen, vitamins, protein and water are all nutrients.

organic

Broadly defined, anything containing carbon. If something is or has been part of an organism, it is considered organic.

organism

Any living thing. Plants, animals and humans are organisms. They can contain complex structures consisting of cells and tissues called organs. The liver and heart are examples of organs.

omnivore

An animal that eats both plants and animals.

persist

To continue in existence such as when a substance remains in the environment for a significant period of time: endrin, for example.

photo-synthesis

The process by which green plants make food energy with the help of sunlight, water and carbon dioxide. Oxygen is released.

pollinate

The fertilization of plants, often with the aid of bees that transfer pollen from flower to flower.

red-blood cells

Blood cells containing hemoglobin. Hemoglobin is an oxygen transporting red pigment in blood and contains the element iron.

regulations

Rules or laws that control one's actions. For instance, if regulations are violated, a person may be fined or put in jail.

residue

Remaining material after completion of a process. After pesticide application, chemical residues often remain in the environment.

risk

The chance of injury or harm.

runoff

The process by which chemicals can enter streams. As rain falls onto pesticide sprayed fields that are drained by streams, the chemical is carried in the drainage water.

sediments

The accumulation of material at the bottom of a body of water.

seedlings

The early growth of a plant out of seeds.

sewage

Waste liquid and matter carried off by a system of underground tunnels or drains.

soluble

Able to dissolve in a liquid. Water-soluble chemicals can easily dissolve in water. Other chemicals dissolve more easily in organic solvents, such as alcohol.

solvent

A substance that dissolves another substance. Water, for example, can dissolve sugar. Turpentine can dissolve oil-based paints.

suffocation

Death caused by the inability to breathe.

synthetic

Man-made. Synthetic chemicals are those that do not occur naturally.

synthetic soaps

Laundry products made from chemicals.

target organisms

The organisms intended to be killed by a poison, such as insect pests and weeds.

toxicology

The study of how substances can cause harmful health effects in organisms. The basic science of poisons.

trace metals

Metals required in small amounts by organisms for maintaining good health such as iron and zinc.

transformers

A device that changes a current of electrical energy to a different voltage. Electrical transformers can take high voltage electricity in power lines and transform the voltage to a level that people can use in their homes for cooking and lighting.

toxic

Poisonous. Toxic materials cause harm to biological organisms.

toxin

A poisonous substance. Chemicals capable of causing harm to the living tissue of plants, animals and human beings.

virus

Microscopic agents that can inflict disease or infection. Polio is caused by a virus.



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